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THE LEY AND SOIL FERTILITY IN BRITAIN AND KENYA

The ley has only been introduced into farming in Kenya relatively recently and as yet only to a limited extent, but its much wider use as a means of maintaining soil fertility and increasing production in a mixed farming system is frequently strongly advocated. To what extent can the claim that the ley is a fertility builder be justified by the very limited knowledge of its efficacy so far gained in Kenya, or by the application of experience obtained in Britain? Some reflections on this question were prompted by a recent visit to a number of ley fertility experiments in Britain, and this note attempts to summarize some of the results there obtained and to suggest how they may perhaps be modified under Kenya conditions.

In Britain, the emphasis which is nowadays placed on the advantages of ley farming is supported by a great deal of practical experience of the very satisfactory level of production of crops and stock which can be maintained under this system over a long period. In the ley farming system, however, the resting of land under temporary pasture is by no means the only factor contributing to soil fertility: for example, considerable quantities of farmyard manure and fertilizers are also used. Direct experimental evidence of the effect of the ley *per se* on fertility is limited and is not universally regarded as conclusive. Furthermore, while there may be a general consensus of opinion that the ley in itself is beneficial to the soil, it is evident that there is, as yet, no clear understanding of *how* it exerts its beneficial effect nor any very precise measure of the increase in crop yields which results.

The probable beneficial effects of a grass/clover ley on soil fertility in Britain may be due to several or all of a number of interacting physical, chemical and biological factors. Physically, there may be an improvement in "soil structure", due to a favourable aggregation of the smaller soil particles into crumbs, and resulting in increased porosity, better percolation of rainfall, improved movement and supply of soil moisture and air to the roots, easier or better cultivation and improved tilth. Chemically, the supply of total plant foods, especially nitrogen, in the surface soil, may be increased, and some nutrients may, by the action of the ley, be rendered more readily available to the crop plant. Biological benefits may result from an increase in the number and activity of the soil macro- and micro-organisms which may bring about an improvement in both the nutrient and physical status of the soil.

There is a number of ways in which leys may bring about these effects, amongst which the following are probably the most important—

(1) An increase in organic matter resulting from the abundant root system of the ley and the ploughing-in of large quantities of herbage. Organic matter is undoubtedly very important. It improves the physical condition of the soil, both by its mere bulk and by its decomposition products, which include fungal slimes having a cementing action aiding crumb formation. It contains plant foods, especially nitrogen, which become available to crops as the organic matter decomposes, and it is a principal factor in the maintenance and increase of the soil flora and fauna. Apart from the micro-organisms one should not forget the larger soil animals, of which the earthworm is probably the most important. Earthworms can only flourish in soil which is well supplied with organic matter, and their activities are much greater in established leys than in normal arable soil. The direct effect of earthworms on plant growth has never been settled, but the casting species ingest soil particles along with organic matter and pass out a mould which is admirably suited for plant growth: in doing so they help to keep the surface soil loose and well aerated and may also play an important part in converting plant residues into humus. It may well be, then, that the effect of the ley and its residual organic matter in increasing earthworm activity is of some importance.

(2) An increase in the nitrogen content of the soil, brought about by the fixation of this element by efficiently nodulating legumes.

(3) An increase in the amount of other nutrients readily available to the following crop plant. The deeper rooted herbage plants will draw up nutrients from the lower soil layers and, when the ley is ploughed in, leave them concentrated in the surface soil. There is also evidence that certain legumes and, possibly, some grasses, either by reason of their root exudates or by some other means, can break down and absorb forms of phosphate, and perhaps potash, which the common crop plants cannot utilize, and can leave these nutrients in a more readily available form for the following crop.

(4) The close network of fine, fibrous herbage roots, together with the still finer root hairs and their associated concentration of colloids and micro-organisms, may have a beneficial mechanical effect in binding soil particles into crumbs, and also some chemical and biological action of value.

Finally, it is important to keep in mind two ancillary effects associated with the ley. Firstly, there is the effect of the grazing animal which may be physical, due to treading and consolidation; chemical, due to the return of part of the nutrients in a relatively available form in the dung and urine; or biological, due to the presence of micro-organisms, and possibly hormones, in the excreta. Secondly, there is an undoubtedly important purely rotational effect of the ley in reducing the incidence of certain plant diseases or the degree of infestation of the land with certain weeds.

Much recent experimental work in Britain aims not only at measuring with some accuracy the increase in crop yields brought about as a result of the ley, but also at finding out the relative importance of some of the above factors in producing improvements in yield and soil fertility, taking into account, in addition, other fertility-building practices normally inherent in the ley farming system. A number of somewhat complex and long-term field experiments have been started. Some of these include a comparison of leys of grass only, grass and legume, or legume alone, in order to assess the importance of the legume and of the nitrogen fixed by it. Leys of varying duration are also compared, and observations made of their effects on build-up of soil structure and nutrient status and on the yields of following crops. Grazing of the ley is tested against cutting for hay, silage or dried grass. Various rates of application of fertilizers, especially nitrogen, are included, together with the comparison of farmyard manure versus nil. The majority of these experiments have been started so recently that there has not yet been time for them to give definite results but some indications are available from the earlier trials.

Evidence on the effect of the ley in producing an improvement in soil structure, and the part which this plays in determining the yields of following crops, is by no means conclusive and contrary results are often obtained. For example, in one experiment, continuous arable cultivation was compared with rotations including one, two and three-year leys. The yields of the kale crop following these treatments, together with the laboratory determinations of soil structure, were nicely of the ascending order: continuous arable, one year, two year, and three-year leys, thus apparently demonstrating the beneficial effect of leys of up to three years duration on the following crop yields through the medium of the improved soil structure. On the other hand, in another trial on the same station, a comparison is made of crops grown on two soils, one regarded as having very poor structure (after long cultivation) and the other as having good structure (after eight years grass), but, although yields were better on the "good structured" soil, the laboratory figures for soil structure determinations did not correlate at all well with the yield figures. Similar difficulty has been experienced at other centres in demonstrating, by laboratory measurements, consistent differences between soils of apparent different structure and in correlating such figures with crop yields. When it is remembered that such laboratory measurements are only attempts at empirical estimation of the complex of physical factors known as "structure", it is not very surprising that correlations with yield sometimes occur and sometimes do not.

It is clear that the structure of the soil under really old grass is superior to that under leys or under cultivation. When long-cultivated land is put down to grass, it seems probable that the structure builds up relatively rapidly over the first three or four years, to a level somewhat below that of old grassland, and

that thereafter the improvement is very gradual. Conversely, when land is broken from old grass, structure runs down rapidly for three or four years and then declines much more slowly. The ley of three or four years' duration undoubtedly has a beneficial physical effect on the soil, but this is probably limited, of relatively short duration, and not always reflected in following crop yields. Its effect on crop yield is most likely to be apparent with a winter-sown cereal in a season which is difficult for tillage operations: when weather conditions for cultivation are good, and especially if the crop is spring sown, it is quite likely that the effect may be small or absent.

There is much more evidence to indicate the importance of the increase in soil nitrogen resulting from the presence of nitrogen-fixing legumes in the ley. Comparisons of one year or three-year leys of grass alone, grass and clover, or clover alone, have resulted in the yields of crops being best after clover, next best after grass and clover, and least after grass alone. The addition of heavy dressings of nitrogenous fertilizer to crops on continuously cultivated land has raised yields to almost, if not quite, the same level as those obtained on land after a good ley. In various parts of the world estimates of the amount of nitrogen fixed by clovers have varied from 50 to 200 lb. per acre, but it is not clear as to how much of this may be leached beyond the reach of the plant roots or otherwise lost.

On the whole, experiments have indicated that the grazed ley is more beneficial than that which is mown for hay or otherwise conserved. This, however, means little as it is not possible to say whether it is due to a direct effect of the animal, or merely because under grazing a greater proportion of the nutrients removed in the herbage are returned to the soil than when the ley is cut for conservation. It is likely that experiments now in progress will throw some light on this matter.

To summarize the impressions gained. In Britain there is a good deal of evidence to show that the ley farming system, which includes fertility-building factors other than the ley itself, is satisfactory in maintaining or improving soil fertility and crop yields. Experimental evidence of the beneficial effect of the ley *per se* is more limited but, although not accepted by all, is probably valid. The magnitude of the beneficial effect, as measured in crop yields, or the way in which the ley brings about this effect, is much less certain. The beneficial effects are certainly due to a complex of factors and the importance of individual factors will vary with soil and local conditions. Nitrogen fixed by legumes in the ley is probably the most important single factor. The ley improves soil structure, but probably only to a limited extent, not for long, and not necessarily to a degree which raises crop yields. Mere rotation of arable crops with leys commonly has a marked beneficial effect by reducing weed infestation and disease incidence.

Turning now to Kenya, it at once becomes evident that one cannot generalize about the effects of the ley over the wide range of soil and climatic conditions found in the Colony. To take somewhat extreme examples, the ley cannot improve the structure of the very sandy soils, in the manner generally understood, as such soils cannot form crumbs to any appreciable extent, while in the drier areas the rainfall does not permit the establishment of a really effective ley. Discussion must therefore be confined to areas with a rainfall of at least 25–30 inches and to soils which are not very sandy.

There is some evidence that, under favourable rainfall conditions in the Highlands, the rotation of arable and ley gives higher crop yields and is better for soil fertility than a system of continuous cultivation. Reduction in soil erosion and decreased incidence of weeds and diseases are partly responsible for this. Evidence of a beneficial effect of the grass ley itself on soil fertility and crop yields, or of its superiority to other methods of maintaining fertility, is scanty and inconclusive.

In one important respect it is fairly certain that the ley exerts a beneficial effect in the same way as it does in Britain—by drawing up plant nutrients from the deeper soil layers and leaving them concentrated in the surface. But apart from this it would be a mistake to assume that the ley will work in the same way as it does in Britain under the very different soil and climatic conditions of Kenya. There are, in fact, several circumstances which may militate against it being able to do so. In the first place, the ley in Britain is normally a mixture of grasses and clover, and the importance to soil fertility of the nitrogen fixed by the clover has already been noted. The ley in Kenya, except in those limited areas where indigenous clovers flourish and appear spontaneously, is at present of grass only, so that the addition of fixed nitrogen to the soil does not usually occur. Furthermore, turning in organic matter low in nitrogen will cause the

micro-organisms responsible for its decomposition to remove available ammonium and nitrates present in the soil, so that a temporary shortage of available nitrogen will result. This is probably the chief cause of the mediocre yields which are not infrequently experienced when a crop is planted after ploughing in a grass ley and before the herbage residues are adequately decomposed. Even if legumes are present in the ley, it is by no means certain that they will behave as they do in Britain, as there is evidence that some local legumes do not fix nitrogen effectively under natural conditions. This matter is being studied, and it is possible that the difficulty may be overcome by inoculation with appropriate strains of nodule bacteria or by the addition to the soil of certain essential elements the absence of which prevents the legumes from functioning efficiently. We cannot, however, be certain that the addition of fixed nitrogen by the legume component of the ley will prove as important in Kenya as it appears to be in Britain. The evidence from quite a large number of fertilizer experiments, carried out over several seasons in the Highlands, was that wheat showed little or no response to nitrogenous fertilizers while the response of maize was variable but rarely of economic importance. As lack of other major nutrients was not a limiting factor in these trials the results are contrary to expectations, but they clearly make it impossible to be definite about the probable effect of the nitrogen which would be contributed if efficient legumes were present in a ley.

Secondly, under tropical conditions, especially where there is a long dry season with high temperatures, organic matter added to the soil by a ley will decompose and disappear much more quickly than it will in Britain. This is particularly true of the lower and warmer areas, but it will also apply to only a slightly lesser degree over the greater part of the Kenya Highlands. Consequently, the effects of organic matter in increasing the nitrogen content of the soil, in supporting greater microbiological activity, and in improving soil structure, are likely to be transitory. The improvements in the structure of tropical soils which can be brought about by organic matter or by other factors, are in any case somewhat doubtful. There is evidence to show that, although leys of three or four years' duration do have some beneficial effect on soil structure in East Africa, this improvement is not great and has entirely, or almost entirely, disappeared within a year of bringing the land under cultivation again. This is probably due partly to the rapid oxidation of organic matter, partly to the nature of tropical soils, and partly to the greater intensity of tropical rainfall.

So little is known about the flora and fauna of tropical soils that the effect of leys, or of transitory increases in organic matter, on biological activity must be largely an open question. Earthworm activity is negligible compared with that found in Britain, but it is quite likely that the performance of similar functions, by other soil animals, such as termites, may be of importance.

Thirdly, although there is no clear evidence either way, it is quite possible that, except in areas of really favourable rainfall, the ley may have an adverse effect on the soil moisture available to following crops. There is no doubt that in many parts of Kenya soil water is the most important limiting factor to crop production and it is quite possible that the ley, while it will undoubtedly check run-off and increase percolation of the rainfall, may consume and transpire so much water during its growth, that the soil is left in too dry a condition to support optimum growth of a following crop. It has been shown that species such as Kikuyu and elephant grass, which are deep rooted and also continue growth through part or the whole of the dry season, can dry out the soil to a marked extent. The common ley species tend to cease growth soon after the end of the rains, but it will clearly be the effort of the pasture research worker and the farmer to find means of keeping leys in productive growth as long as possible into the dry season, and we know little about the depth to which the root systems of the various species will penetrate and draw on the soil moisture. In fact, the effect of the ley species on the soil water balance has not yet been adequately studied and no definite statement on the matter can be made, but it is certainly a factor of great importance which needs thorough investigation.

Despite all these uncertainties as to the value of the ley in Kenya, the introduction of alternate husbandry in the wetter areas, particularly in the Highlands, can be justified on the grounds of its superiority to continuous cultivation, of its effect in checking or eliminating erosion, and of the indisputed value of good grass as a stock feed in a mixed farming system.

C. C. WEBSTER.

FOOT-AND-MOUTH DISEASE

"The need for greater understanding of foot-and-mouth disease is so great that we make no apology for devoting much more space to this subject than is our usual practice." In these words, the Editor of the *British Agricultural Bulletin* justifies the inclusion in the issue quoted above of a long well-illustrated article by a member of the Headquarters staff of the Animal Health Division of the British Ministry of Agriculture.*

Foot-and-mouth disease first made its appearance in Great Britain in 1839, and from then until 1896, the country's livestock suffered repeated epizootics. The disease was first made notifiable in Britain in 1869 but it was not until 1892 that the decision and power to adopt the slaughter policy was taken. From that time the legislation has had as its objects:—

(1) Banning the importation of livestock from countries in which foot-and-mouth disease exists.

(2) Preventing the introduction of the disease by regulations controlling the importation of animal products and potentially contaminated material.

(3) Eradicating the disease whenever and wherever it appears, by the application of the stamping-out method by slaughter.

The knowledge that only by such a drastic policy had rinderpest been eradicated from Great Britain in 1877, influenced the Government and the stockowner to apply the policy to foot-and-mouth disease. In addition, British stock was beginning to assume such high value for export purposes that the economic repercussions of an enzootic state of infection would have been serious.

The cause of the disease is a filtrable virus which survives in beef and beef offals so long as these are kept frozen. As regards virus outside the animal body, a low temperature and a dry atmosphere are found to be favourable to its survival, but putrefaction fails to destroy the virus in three weeks. The disease spreads from the affected to the susceptible animal with even greater ease and rapidity than does the common cold or influenza infection of humans. Infection is spread by such intermediate agencies as human beings and their contaminated clothing, vehicles, feeding utensils, packing materials, rodents and birds.

There are several types of the virus which although immunologically distinct all produce similar clinical lesions in susceptible animals. An animal which has recovered from infection with one type of virus will carry immunity to that type but not to other types. An animal can be attacked by one type of virus after another and therefore be an economic loss to its owner and the country for long periods. Immunity to any type of virus is not permanent. It wanes within a year. An animal may be again attacked by the same type of virus and again have to go through the long and costly convalescent period.

The immunological differences between types of virus have been the subject of much research because this problem is closely bound up with the endless search by scientists for a satisfactory polyvalent vaccine.

This complication of various types of the virus and even variants of each type means that any system of control by vaccination requires very complete organization which must also involve control of movement and other restrictions. With a quickly spreading disease like foot-and-mouth requiring vaccination of a large number of animals the cost is very high.

In France a vaccination campaign from September, 1951, to October, 1952, cost not less than three million pounds. This figure is approximately equal to the amount of compensation paid to British stockowners over the same period. Despite the expenditure France suffered over 313,000 outbreaks with loss from deaths, abortions, reduction in milk and meat estimated at one hundred million pounds.

The mortality in foot-and-mouth disease is not usually high. In adults, deaths may be about 1–2 per cent but in young stock especially unweaned calves, the mortality may be as high as 50 per cent.

It is necessary to explain at length why such severe measures are taken to suppress a comparatively non-fatal disease in countries where the cost of eradication is not too high.

In the early stages of the infection there is a high temperature, and as a result of the

* Reid, J. (1954), British Agricultural Bulletin, Vol. 7, pp. 24–30.

foot-and-mouth lesions the affected animal is in severe pain, with a consequent marked reduction in milk yield in dairy cattle and rapid loss in condition in beef animals. As the disease passes through the herd its earning capacity is greatly reduced and the animals cost more to feed, nurse, and tend. Pregnant animals abort and permanent defects in the udder reduce the value of cows.

Further, a slaughter policy which means the complete destruction of all animals on infected premises ensures that no partially immune or recovered stock remain alive. Consequently, a new outbreak can be detected very quickly since sub-clinical disease which can spread infection without suspicion is eliminated. The fully susceptible animal develops the classical symptoms which enable owners and veterinarians to recognize the disease at an early stage and take eradication measures before spread takes place.

It is for these reasons and because of its extreme infectivity which carries the disease quickly across countries and continents that Britain, Ireland, America, Canada, Norway and the Union of South Africa where the disease is not enzootic, have chosen and satisfactorily employed the slaughter policy in dealing with foot-and-mouth disease.

In order to carry out this policy very careful organization is required with staff available to deal with outbreaks as a matter of extreme urgency. It could not be successful without the willing co-operation of the livestock industry, for it depends essentially on early notification of disease and acceptance of what at first sight would appear to be drastic measures of control.

Such measures have succeeded in preventing the disease from becoming enzootic in Britain and so it is possible to offer to buyers from overseas a pedigree animal, neither recovered from, suffering from, nor incubating foot-and-mouth disease.

—Inter-African Bureau for Epizootic Diseases, Muguga,

REVIEW

Jute Substitute Fibres, by A. E. Haarer, with a foreword by Sir John Russell, published by Wheatland Journals, Ltd., London (1952), price thirty shillings.

The present production of jute is insufficient to meet world requirements, but there are relatively few parts of the world with suitable soils and climates and an abundance of cheap labour. Consequently the expansion of jute cultivation is difficult, and a search is being made for substitutes which can be planted, harvested, and processed by mechanical means and which can be grown in a wider range of soils and climates.

In this book the author deals fully with three fibre plants: Bimlipatam jute (*Hibiscus cannabinus*), Roselle (*Hibiscus sabdariffa*), and Aramina fibre (*Urena lobata*). He has collated all the available information on climatic requirements, cultivation, harvesting, and processing, but he was handicapped by the fact that many jute substitute fibres have been tried out only on a small scale and have been processed by methods which were not always suitable or successful. In consequence, samples of Bimlipatam and Roselle which have been tested for their suitability for manufacture have varied so widely in their physical characteristics that it is difficult to assess their true potential value. It appears that, in order to produce a substitute for jute on a commercially successful scale, the information contained in this book should be used as a guide in seed selection, variety trials, cultivation experiments, tests of harvesting machinery, and research into methods of fibre extraction, processing, and utilization. Small-scale trials and haphazard experiments with processing methods will only confuse the problem.

Each of the three fibre plants described has chapters on botany, properties of fibre and seeds, selection and breeding, cultural and climatic requirements, and harvesting, retting, and extraction of fibre. Diseases and pests are dealt with in an appendix, and in a chapter entitled "Summary" the author discusses the problems of commercial fibre production in more general terms.

D. W. D.

THE EAST AFRICAN HIDE AND SKIN SURVEY

By R. L. Sykes, E.A. Tanning, Hides & Allied Industries Bureau

(*Received for publication on* 10*th June*, 1954)

It is nearly ten years since French [1, 2, 3], writing in this JOURNAL gave a very adequate description of the East African hides and skins trade, and a review of the factors which affect the quality of the products and therefore the value of the trade as a whole. Since that time many developments have taken place, and the value of the trade has increased to approximately £4,000,000 per annum, the latter figure being the average over the last four years. Apart from the expansion of the trade in relation to overseas markets, many other developments have taken place within East Africa. The extension of the Hide Improvement Services run by the territorial Veterinary Departments has done much to improve the quality and handling of the raw stock. In addition, the East African Hides, Tanning and Allied Industries Bureau, a High Commission Department, has helped to co-ordinate the activities of the three Governments and to maintain satisfactory relations with the hides and skins trade. A section of its activities is the development of the E.A. hides and skins survey which is the subject of the present article. The survey, part of a projected port examination service, was commenced on a small scale in 1951 and gradually extended until it covered all three territories by the end of 1952. 1953 was therefore the first full year in which the survey was working throughout the mainland territories of East Africa, and during the year over a quarter of a million hides and skins were examined. Figures showing the proportion of total exports examined are shown in Table I. With the gradual extension of the service a number of variations were found in the day-to-day working in regard to the different approaches made by the Hide Examiners who carry out this survey. During the early part of 1953 some modifications were made in the way in which the Examiners reported the results of their work, mainly with a view to standardization. These modifications have done much to increase the value of the survey as a whole and to make the information contained in it more reliable.

Its primary object is to examine hides and skins at bottle-necks in trade supplies, for instance at the ports of Mombasa, Tanga and Dar es Salaam, where hides and skins are delayed prior to their export to overseas markets. Other examinations are made at Moshi, which is the natural outlet of skins originating in the Northern Province of Tanganyika, and which are exported overseas through the port of Mombasa. Another examiner is based on Kampala and covers the majority of Uganda, making surveys of the hides and skins produced in that territory. The examination is confined to visual faults which can be seen in the dried hide or skin. It will therefore be appreciated that the survey is not a complete one, as a number of faults, particularly those affecting the grain, may not all be apparent until after the hide or skin has been put into process by the tanner and the hair has been removed. Apart from the faults which occur, the method by which the hide or skin has been dried is also recorded. It should be remembered that certain other faults may affect East African hides or skins which are not examined by our staff. We do feel, however, that our survey is covering all the important faults of East African stock so far as is possible by a visual examination. The figures to be quoted in Tables II and III are summarized ones which refer to East Africa as a whole. More detailed breakdown into seasons and into the various territories are to be found in the Annual Reports of the East African Hides, Tanning and Allied Industries Bureau [4, 5].

DRYING METHODS

Although only two classes of drying methods are recognized by the trade, namely suspension and ground-dried, the Bureau reports on four different methods. Suspension-dried hides are those dried in frames. Goat and sheep skins may be suspension-dried in two ways, either in a frame or over a wire. Both methods are legally allowed by the various Hide and Skin Trade Ordinances. The advantages of suspension-drying are that usually the hide or skin is dried somewhat quicker and under a relatively even tension. Owing to the fact that it is off the ground it is less likely to be dirty, since some care has obviously been necessary to suspend the hide or skin. It is also probable that more care will have been taken over the removal of excess fat and flesh tissue from the hide or skin. Other hides or skins which are

dried in the traditional native manner of merely throwing or pegging on the ground, usually with the flesh side uppermost, are inevitably of a lower quality. Drying is uneven as only one side is exposed to air movement, and, in addition, over-heating may occur. The relatively high temperatures (up to 70°C.) which are exerted on the moist skin may cause two types of change, both of them depreciating the quality of the hide or skin. Direct heat damage, which can cause a physical change in the fibres which constitute the skin, has recently been shown to be possible under conditions which apply in some parts of East Africa during part of the year [6]. The other type of damage is not physical but is due to putrefaction by micro-organisms, a fault which may be apparent in the dry state and which will be dealt with more fully under "Faults". It is due to the fact that much of this damage is not apparent in the dried hide that the trade places a premium on all hides and skins which have been dried by the suspension method. It can be safely stated that the general policy of this Bureau and the Veterinary Departments' Hide Improvement Services in East Africa is to eliminate ground-drying completely. During the past ten or 15 years there have been very considerable reductions in the proportion of ground-dried hides produced and exported. By means of the survey which is carried out, it is possible to check whether this improvement is continuing and also to get some idea as to whether the exporters' customs declarations are to a reasonable extent correct.

A small number of hides and skins are dried by other methods, either over wire racks, on poles or by the so-called "tent" method in the case of hides. Goatskins are sometimes dried in the "cased" condition where the skin has not been completely opened out, and in practice one layer is superimposed upon the other during drying. Only about one or two per cent of all stock is dried by any of these minor methods. At the present time less than 15 per cent of the exported stock is ground dried; this represents a very considerable advance since 1939, when only about 15 per cent of stock was suspension dried. Not only is a premium paid for suspension-dried stock, but also there is with it a general improvement in East African hides and skins as a whole. These have contributed to the very great increase in the value of the East African hides and skins trade, which has risen in value by approximately 800 per cent since the years just before the war.

FAULTS

Faults occurring on the living animal.—Owing to the conditions under which many animals are kept in East Africa, many faults occur on the hide or skin before the animal has been killed. Five types of such damage are dealt with in the Bureau's survey.

Disease.—The various animal diseases which affect the surface of the animal's body, i.e. the hide or skin, can do a great deal to lower the quality and hence the value of the latter. A qualified veterinarian would give many of the diseases different names, such as demodectic and sarcoptic mange, streptothricosis, etc., but for the purposes of the Bureau's examination, all are simply classed as disease. The survey has shown that between 25 and 30 per cent of all East African hides and skins have been subject to sufficient damage to cause their down-grading by the disease factor alone. Whilst few of these diseases will render a hide or skin completely useless, they will reduce the intrinsic quality on which the value of the resultant leather depends to a great extent. The reduction in the extent of disease is more a problem for the Veterinary Research experts than the Hide Improvement Services. It is probably quite true that virtually no stock is produced in East Africa which is completely free from disease, but it is only that which would be sufficient to cause down-grading which has been recorded in our survey.

Sores.—Many of the sores which are found on East African stock arise from clinical sources, and are directly attributable to boils or possibly to general deterioration of the hide or skin following infestation by ticks or other irritant parasites. Other sores follow wounds which the animal has received by physical cruelty from the herd boys who usually control much of the stock. General enlightenment of the population is probably the only way in which this sort of damage will be eliminated. Increased fencing in the native reserves with a consequent reduction in the mass movements of cattle would also help.

Branding.—Although not confined to cattle, the majority of branding does occur in cattle hides and in some areas at least 25 per cent of the stock examined by the Bureau's staff is classed as damaged by branding. Branding is sub-divided into two types, "Tribal Brand-

ing" and what we call "Other". Tribal brands are applied to the stock by the indigenous owners, many of whom for a variety of reasons are concerned either with some mystic or religious ceremony, or with protection against disease. It is also possible that some of them indicate ownership but even so the majority of them are unnecessarily large and cause permanent damage to large areas of many hides, so much so that on occasion the whole hide has to be discarded as useless for leather production. Cruelty to the animal is inevitable when some of these large brands are applied. It is felt that increasing African education should do much to eliminate this form of damage. A second type of branding which is classed as "Other" is usually small in comparison with the amount of tribal branding, but is nevertheless not insignificant. It relates to either ownership or veterinary brands which are incorrectly placed. Legislation is enacted which states that brands indicating, for instance, place of origin, should be of a specified size and placed on the fore shank. Carelessness in applying these brands gives rise to irreparable damage on the hide or skin. Brands indicating that the animal has been vaccinated, for example, against rinderpest, are usually in the form of an -R- which should be placed either on the hump or on one of the shanks, usually the fore shank. If these brands are correctly placed, they will ensure that the minimum damage has been caused to the hide or skin. Brands indicating ownership, which are often placed on cattle by the larger ranchers, can also cause irreparable damage and loss of a part of the total hide area. Satisfactory brands or marks can be applied to the head or shanks which will be sufficient for identification by the owner. There is little excuse for placing these brands in the middle of the butt area of the hide where they will cause a maximum reduction in value.

Scratches.—With the large herds of stock which are free to roam about the unfenced and scrub-covered plains in East Africa, it is easy to see why large numbers of hides and skins are damaged by scratches of one kind or another. Many of these scratches do not become visible until the hair is removed, and hence the figures obtained from our survey reports are likely to be considerably lower than the true value. It is unlikely that there will be any great reduction in the number of scratches from this cause until there is more enclosure of land.

Barbed wire, which is sometimes used in the construction of boundary or paddock fences, is also another cause of scratches on the hide surface. Apart from the scratch itself, very frequently a wound is caused which begins to fester and therefore increases the actual area of damaged tissue. Scratches can also come from the horns of other animals and are commonly called "horn rakes". In our survey, the effects, which are similar on the finished leather, are not recorded as two separate items, as it is often difficult to distinguish them when the skin is in a dried state. Horn rakes come when animals are herded closely together or when they fight. In most domestic animals the horns have become a useless appendage and there would seem to be no reason why stock should not be budded when very young. This operation is simply carried out and would ensure the elimination of one type of easily preventable damage. It is possible that the extensive introduction of budding would meet with some objection from traditional interests: its encouragement is, however, to be advocated.

Faults Arising During Flaying and Drying

Flaying and Preparation.—The majority of flaying damage is attributed to knife cuts and scores which come about through the incompetent or careless use of the knife by the butcher who is removing the hide or skin from the carcass. It is probable that damage caused by flaying is the biggest individual factor causing down-grading of East African hides and skins. It is hoped that with continual teaching and instruction by Hide Improvement Officers and their African Assistants a more extensive reduction in the amount of flaying damage will be observed.

Furthermore, the correct type of flaying knife has now been defined in some of the territorial legislation [7] and its enforcement will do much to remove many of the cuts which were unavoidable when "sheath" and even kitchen knives were used by the butchers or their assistants. Also, and particularly in Tanganyika, the official encouragement of hammer-flaying which completely eliminates the use of knives after the carcass has been ripped, will also have an effect in reducing damage by knife-cuts during flaying. In addition to the damage which is caused when the carcass is flayed, other knife-cuts and gouges can occur when the flayed hide or skin is being

cleaned, i.e. surplus fat and flesh tissue removed from the flesh side prior to the stock being put out to dry.

Whilst in the case of goat and sheepskins the whole area is of approximately equal value, cattle hides are usually divided in England by the tanner into two portions, classed as "butts" and "offal". The offal consists of the two flanks and also the shoulder part of the hide. These parts have a very considerably lower leather-making potential than the butt area, which is roughly equivalent to the back of the living beast. In the case of hides it will therefore be seen that it is particularly important that there should be no damage on this part. Damage to hides on the two areas is therefore recorded separately and the attention of the producer is particularly drawn to the elimination of any damage on the butt area. Our survey has shown that the amount of flaying damage in Uganda is on the average less than in the other East African territories. It is possible that much of this reduction can be attributed to the policy of green hide buying which is encouraged by the Uganda Veterinary Department. Green hide buyers obtain the undried hides and skins from the butcher and make their livelihood by cleaning and drying the stock prior to its sale for export. It will be seen therefore that their main source of income usually comes from the production of high quality hides and skins; to a butcher the hide or skin is only a by-product of lower value and may therefore be subject to less careful handling.

Putrefaction.—Experimental work has shown that in the vast majority of cases putrefaction of any sort is due to carelessness on the part of the producer. Much putrefaction is not apparent in the dried state and therefore the figures which are obtained by the survey may tend to be low for this fault. Its identification in the dried skin usually comes from the condition known as "hair slip". In cases where it is apparent, it is possible to remove the hair quite easily by rubbing the surface of the hide. Putrefaction usually arises from delay in cleaning the hide or skin after the animal has been flayed when, as is often the case, it is left lying in pools of blood or covered with dung and filth; the action of putrefactive bacteria then commences very rapidly. The obvious solution is to encourage the rapid cleaning of the hide or skin after flaying. Whenever water is available they should also be thoroughly washed to remove any contamination of blood and dirt before they are put out to dry. Under certain climatic conditions putrefaction may also occur during very slow drying. However, experiments have been carried out which show that even in the rainy periods when the humidity remains continually high it is possible to dry both hides and skins satisfactorily, providing they are cleaned soon after flaying and put out to dry with the minimum of delay [8]. It is possible that in the larger centres the application of an antiseptic to the wet skin before it is put out to dry, or immediately after it has been put on the frames or stretched over the wire, will do much to reduce the development of putrefactive organisms. In addition to the general putrefaction which may arise from either carelessness or extremely unfavourable drying conditions, marginal putrefaction may take place if free air movement is restricted by having a part of the hide or skin in contact with some solid object. The method of pole-drying hides and skins which is occasionally practised is bad for this reason. Usually, where the hide has been lying in contact with a relatively thick pole, a line of putrefaction can be seen. This condition may also arise around the edges if the frames on which hides have been dried are too small and some folding has taken place. The obvious remedy for this sort of damage is to build the correct size of frames.

Bad Pattern.—The correct ripping lines from removal of the carcass have been demonstrated in a number of books published in East Africa [9, 10], and also in territorial legislation. It is still unfortunately quite a common occurrence for incorrect ripping lines to be used by the butcher. The result of this is that the hide suffers from what is termed "bad pattern". In other words, the line of the backbone is not perpendicular to the rear end of the hide. Although to some this may not seem to matter, it must be remembered that the hide is cut into approximately rectangular pieces by the tanner, who expects the substance to be uniform. This crossing by the backbone and also the consequent inclusion of parts of the belly leads to a reduction in the quality and hence in the market price of the leather which is produced. It is therefore essential that adequate attention should be paid to the correct ripping of the animal. Any information which can be obtained from the survey as to the origins and extent of this sort of damage is of immediate value to the Hide Improvement Services.

Smoke.—This is another form of completely avoidable damage which still occurs in East African hides and skins. The survey shows that the incidence is largest in the Northern Province of Tanganyika and may be due to the slow drying conditions which prevail during parts of the rainy seasons. Whenever the moist hide or skin is subjected to the action of smoke, a form of primitive tannage occurs. This means that the overseas buyer of the hide or skin is not getting raw stock but a partially tanned product which will not behave in a normal manner during processing. It can usually be detected merely by smelling the hide, when the odour of wood smoke is still apparent many weeks after drying has been completed. Every effort should be made to encourage the elimination of smoking hides. It is also possible that smoke damage to a lesser extent occurs when the nearly dried hides are taken down for storage inside native huts which are heated by open wood fires.

Faults Occurring During Storage

After hides and skins have been dried, very considerable delays may still occur before they are moved, anything up to 1,000 miles, from up-country areas down to the ports where they can be shipped overseas. During this time they are subjected to further damage, all of which is avoidable providing that adequate care and the proper means of protection are used.

Insect Damage.—Whilst the amount of insect damage at the present time is relatively small, i.e. 3 to 5 per cent, it is still an unnecessary form of damage which can be avoided. It is mainly caused by one species of beetle, *Dermestes vulpinus*, commonly known as the "hide beetle", although ants have also been known to attack dried hides and skins. In the past this pest has only been controlled by dipping in solutions of arsenic at the larger centres, usually by exporters. However, with the development of the newer and less poisonous insecticides, there is no reason why either dipping or dusting with insecticidal preparations should not be carried out in all up-country areas and even by the larger producers. Investigations into dipping of the green or undried stock with an insecticidal solution are being carried out in East Africa. This will be of particular interest to green-hide buyers who will then be in a position to protect their stock from the very earliest stage.

Mould.—The survey has shown that the development of mould on hides and skins is at its greatest in the coastal areas and particularly during the rainy season. This confirms laboratory investigations which have indicated that practically all hides and skins are covered with mould spores [11]. They are, however, inactive until the product is stored under conditions of high humidity when the mould develops. The long storage which may be occasioned by shipping delays in the coastal godowns usually encourages the development of mould. In many cases this is only superficial and has little effect on the quality of the stock. Some of the fungi are, however, capable of destroying the proteins contained in the hide or skin, in a similar manner to the proteolytic bacteria causing putrefaction. The importance of adding fungicide in an insecticidal preparation has been appreciated by the Kenya Veterinary Department and the addition of fungicides to the arsenical dips used by exporters may also do much to reduce the amount of damage caused by moulds.

Re-washing.—Re-washing is actually a malpractice which is legally prohibited. It is occasioned by ground-dried hides and skins which usually have a dirty appearance being re-washed or even soaked in water after the hide has been dried and then re-dried on frames for the purpose of sale as a suspension-dried piece. During this time the conditions are frequently admirable for an extension of putrefaction and for other damage to take place. In addition it is an attempt at intentional deceit, as a suspension-dried hide or skin commands a premium for weight and other quality factors over one which has been ground-dried. Towards the end of 1953, possibly because of the drought prevailing in certain parts of East Africa, this form of damage appeared to be on the increase. These facts were noted by the Bureau's Hide Examiners, with the result that it was possible to inform the Hide Improvement Officers to be on the lookout for anybody practising re-washing.

Conclusions

It will be seen that a large amount of information is now available concerning the faults which occur in East African hides and skins. With the extension of either zone or provincial branding which is now taking effect in Uganda, Tanganyika and parts of Kenya, it becomes possible for the Bureau's Hide

Examiners stationed at bottle-necks in the supply lines to check on the source of any type of preventable damage. The information then being available, it can be quickly passed back to the Hide Improvement Officers responsible for the area in which the hides and skins originated, so that he can take action. The value and the accuracy of the survey has been acknowledged by some of the territorial Veterinary Departments who have recently granted permission for the Hide Examiners to communicate the results of their survey directly to the Hide Improvement Officer concerned when sufficient evidence is available. In general it is possible to say that the pattern and the relative extent of the faults occurring in East African hides is becoming more apparent. Certain seasonal variations have been noted and it is quite possible that special attention can be directed to a certain fault which which may only occur in some seasons of the year. It is hoped that it will be of value in the planning of the East African Hide Improvement Services and also as a basis for formulating general policy by the territorial Veterinary Departments.

In addition to its value in East Africa this survey has been greatly appreciated by the overseas buyers of East African products. It gives them a better and more complete picture of what to expect from East African stock and they can estimate the proportion of a consignment containing a particular type of damage. In the course of time it will also give them some indication as to the improvements which are taking place in East African hides and skins. In fact, it is probable that at the present time more information is available as to the extent and type of faults occurring in East African hides and skins than for those produced in any other Colonial territory. Zone and provincial branding may make it possible to pick out areas which produce either very good or very bad hides and skins. At the present time stock is merely marketed as East African and there is no selection such as occurs in some other countries, for example, the separate marketing of the Red Sokoto goatskin in Nigeria. If at any future date it is possible to pick out with sufficient certainty good and bad areas, it is probable that the better ones will command a premium in the overseas market. This will give an additional incentive to producers in the less efficient areas to improve the quality of their stock so that they will not suffer from this discrimination in price. Although a number of improvements have already been made and the value of the overseas trade has greatly increased, it is estimated that at the present time the value of the hide and skin trade is only about 75 per cent of its potential. The loss of approximately £1,000,000 per year in the overseas export market, much of it to hard currency areas, should be sufficient incentive for greater effort to all those concerned in the production of hides and skins and also to those in the Government Advisory Services which help to improve their quality.

TABLE I—PROPORTION OF EXPORTS EXAMINED

	*Approx. No. exported**	*Actual No. examined*	*Per cent examined*
Dried cattlehides	2,460,000	118,093	4.8
Dried sheepskins	1,600,000	22,466	1.4
Dried goatskins	4,320,000	112,534	2.6

* Calculated from Customs returns using the following weight to number relationships:—

1 cattlehide = 7.5 lb.
1 sheepskin = 1.3 lb.
1 goatskin = 0.95 lb.

TABLE II—DRYING METHODS

Method	*Cattle-hides Per cent*	*Sheep-skins Per cent*	*Goat-skins Per cent*
Suspension—frame	83	72	52
Suspension—wire	—	14	36
Suspension—total	83	86	88
Ground	15	13	11
Other	2	1	1

TABLE III—DISTRIBUTION OF MAJOR FAULTS (AVERAGES FOR EAST AFRICA)

Faults	*Cattlehides Per cent*	*Sheepskins Per cent*	*Goatskins Per cent*
Class I—occurring on live animal—			
Disease	25	5	31
Sores	7	3	3
Branding—tribal	12	1	2
Branding—other	3	1	1
Scratches	12	3	5
Class II—occurring during flaying and drying—			
Flaying damage—butt	14 }	37	21
Flaying damage—offal	22 }		
Putrefaction	8	4	5
Bad pattern	2	2	2
Smoking	2	3	2
Class III—occurring during storage and transit—			
Insect attack	4	3	2
Mould growth	2	1	1
Re-washing	1	3	2

N.B.—Normally the presence of a fault is only recorded if it is present in sufficient extent to warrant downgrading from Grade I to Grade II, other faults present not being taken into consideration.

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EAST AFRICAN LEGISLATION CONCERNING HIDES AND SKINS

Kenya.—Hide & Skin Trade Ordinance, Cap. 209 of the Laws of Kenya, 1948.

Tanganyika.—An Ordinance to consolidate and amend the Law regulating the trade in Hides & Skins, No. 8 of 1950.

Uganda.—The Hide & Skin Trade Ordinance, No. 40 of 1951.

In addition, rules prescribed under these Ordinances are published in the Official Gazettes of the three territories.

REVIEW

A REPORT ON CACAO RESEARCH, 1952, published by the Imperial College of Tropical Agriculture, Trinidad, B.W.I. (1953), price eight shillings.

This Report of 71 pages reflects the progress made in cacao research during the post-war years. The previous Report for 1945–51, which was reviewed in this *Journal* (July, 1954) covered a period of reorganization and expansion, and the Report under review brings out the results of much of the work carried out during that period.

Two of the 13 papers in this Report record progress in lines which are worthy of special mention. One of these describes the work of an expedition to the hinterland of Colombia, which brought back ten wild species of *Theobroma* and *Herrania*. Although it will be many years before this material can show results in the plant-breeding work, it provides greatly increased facilities in the search for crosses or strains immune or resistant to Witches' Broom disease.

The second paper of note is on flower setting and fruit development. In the 1938 Report it was shown that a cacao tree may produce 10,000 flowers, which give rise to 138 young fruit (cherelles), only 26 of which develop into mature pods. Studies of cherelle wilt have been carried out over several years, and the present Report records further progress. It had previously been found that cherelle wilt is partly due to water strain and shortage of minerals: more recently an additional factor was found by research workers in Colombia, the hormone level in the tree and developing fruit. The effects of mineral injections into the tree, and hormone sprays applied to the flowers, are described in this paper, and although the results of the first experiments are inconclusive there is evidence that some of the reasons for this have been found. Future work on this line will be of great interest, since an increase in fruit setting and a decrease in cherelle wilt would be of vital economic value to the industry.

It is pleasing to note that even in the very short period during which the new research scheme had been in full operation when this Report was written (2–3 years) there are signs that the increased financial assistance will be amply repaid by fundamental results of eventual commercial importance.

D. W. D.

LIVESTOCK FEEDS INTO HUMAN FOODS*

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The standard of living of a community is reflected in its quantitative consumption of protective foods and animal products of high biological value because they contribute, not only essential amino acids lacking from vegetable proteins, but because their consumption usually runs parallel to the intake of the vitamin B complex. Over much of East Africa, conditions of subsistence peasant farming persist on soils of reduced fertility, and arable land utilization is then directed towards the production of energy-forming diets, which are often deficient in proteins, minerals and vitamins. Population increases are creating greater demands for food, and many exhausted lands are being kept in cultivation whilst new, and often unsuitable, marginal areas are being broken. For sociological reasons, the African desires large numbers of stock, irrespective of their productivity, and so in congested areas these rival claims can lead to acute problems in land usage.

Bearing in mind the need for animal foods by the human population and the need to permit exhausted arable lands to recuperate under grass, efforts must be made to grow the required cereals in other more suitable regions. Transport and sale of grains from such regions to congested consuming areas would enable exhausted lands to recuperate and, at the same time, would form an essential preliminary in converting subsistence into commercial farming. There would then be less need for African agriculturists to devote their main energies to growing their own cereals and they could concentrate more on animal production and thereby obtain the much-needed supplements for their present inadequate diets.

East African standards of nutrition must deteriorate unless more and better human food can be produced per acre. Successful land utilization has always demanded hard work, skill, knowledge, forethought and pertinacity but to these must now be added the urgent application of scientific and engineering knowledge as well as modern developments in management. Consideration must be given to methods for eliminating inefficiency and complacency in the production of human foods, and for employing the unused reserves of technological knowledge now available.

In the more highly developed regions of the world, efficiency of foodstuff utilization by livestock is, inevitably, closely linked with the financial economy. In East Africa, where supplies of foods of high biological value are so seriously limited, the concern should at first be more with material economy and efficiency than with the financial aspects. Ultimately costs of production and distribution must be considered, because it is useless to produce more or better food if the economic status of consumers prevents them from purchasing but, so long as a high percentage of the inadequately fed population shares in livestock ownership, the greatest benefit will derive from immediate increases in the consumption of milk and meat.

Efficiency of Food Conversion

Estimations of foodstuff utilization involve computations on feed consumption and composition, and on the yields and compositions of the products. For milk and eggs the compositions are relatively constant, and large errors do not arise, but the calculations are highly complicated when meat production is studied. The composition of liveweight gains varies with the species, with age, and the level of feeding. In mature animals weight gains are composed almost entirely of edible matter, but in young livestock the increase contains bone and offal as well. Liveweight gains in young stock contain proportionately more water and protein, but less fat, than similar increases in older stock. In dealing with meat production the only valid method for comparing efficiencies of feed utilization is by computing dry matter, energy, protein or fat conversion rates. The following figures are quoted from the United Kingdom [1]:—

* Paper read at a conference on "The Medical, Agricultural and Veterinary Aspects of Food Production and Utilization in East Africa", held at Kampala, Uganda, 24th to 26th March, 1954.

PERCENTAGE EFFICIENCY OF PRODUCTION

	Energy	*Protein*	*Fat*
Cow producing 600 gallons milk in a year	19.5	23.6	5.5
Cow producing 1,800 gallons milk, 3 calves and cow beef in a lifetime	13.9	18.1	4.1
4-lb. hen laying 200 eggs per year	13.3	29.8	4.7
4-lb. hen laying 120 eggs per year	9.0	20.2	3.2
Fattening ox	7.9	8.7	3.5
Bacon pig	22.3	13.3	11.3
Pork pig	22.1	15.3	11.0
Chicken, 4½ lb. at 18 weeks old	8.2	21.8	2.7

These figures indicate the low efficiency with which feedingstuff energy, protein and fat is converted into human food and show that livestock have a lower energy efficiency than steam engines. They show pigs as the most efficient converters of feed energy into human food energy, followed by 600-gallon cows, 200-egg fowls, table birds and lastly by meat-producing animals. For converting feed protein into edible human food, fowls come first either for eggs or meat, followed by 600-gallon cows, pigs and lastly by mutton and beef animals.

The figures quoted refer to normal conditions in a temperate climate but, unfortunately data are lacking on which to make comparable calculations for East African conditions. Zebu cows under African conditions yield between 50 and 100 gallons, and their efficiency as milk producers must be considerably below that of 600-gallon cows. Improved herds of Zebu cattle on Government Experimental Stations rarely exceed an average of 200 gallons of milk per lactation and, allowing for their smaller size and feed requirements, they cannot exceed an energy conversion efficiency of 11.5 per cent. Breeding delays or failure to make the maximum use of available grasses will further depress their efficiencies. The overseas investigations have, however, demonstrated two points which apply equally well to East Africa, namely, that the first step towards increasing the efficiency of milk production is to cull the lowest yielders, and that for maximum efficiency calvings should be arranged so that the flush of green grass coincides with the peak of the lactation curve.

There is evidence that, under intensive East African conditions, the efficiency of pigs is higher than in Great Britain [2]. This higher efficiency is, however, not achieved by the razor-backs sometimes encountered under African conditions of mismanagement.

Local data [2] indicate that poultry, under intensive management, can be equally efficient in East Africa as in temperate regions. This suggests that, under African management and provided diseases can be controlled, poultry both for eggs and for meat will exceed all other livestock in their efficiency for converting feed proteins into edible human food whilst, for utilizing feed energy, even 120-egg birds will excel average African dairy cows, mutton or beef animals. If reared to the size required for the spring chicken trade, poultry will be more efficient energy producers than other African-owned meat animals.

Owing to seasonal losses in weight, the efficiency of producing beef or mutton under African conditions will be extremely low, but against this is the fact that the meat can be produced entirely from coarse herbage of no direct value to man. Efficiency of meat production cannot compare with that of milk, but meat can be walked to consuming centres whereas milk is expensive on transport and possesses poor keeping properties. Furthermore, cattle, sheep, goats and camels can be reared to maturity and sold for meat under arid nomadic conditions which would be totally unsuited for dairy purposes. In East Africa there are large arid areas which are of little use for cultivation, and the only sound basis of utilization is to graze them, in spite of the known difficulties of increasing the numbers of livestock in, or their output from, these areas.

In calculating food-conversion efficiencies, account must be taken of all feedstuffs eaten for non-productive purposes from conception to slaughter. Such non-productive purposes include the growth and development of the offals and skeleton as well as the foodstuffs used for maintaining normal body functions. For the latter purpose, the energy needs, $E = KW^{.73}$ where K is a constant and W refers to the liveweight, so that the larger the animals the greater are the actual maintenance requirements although the proportion of the energy consumed which is expended on maintenance decreases as the size of the animals increases. Consequently when nutritive levels are high the amount of feed energy which is employed for productive purposes is higher when large stock are used, but when feed supplies are limited smaller animals have a chance of obtaining a surplus over their maintenance needs, at a time when larger animals may be unable to collect sufficient foodstuffs for maintaining themselves.

In addition to supplying energy for basal metabolic needs, the maintenance portion of a ration has also to provide the energy for walking in search of foodstuffs. On poor East African grazing more energy is spent in collecting foodstuffs than on the improved pastures of more developed countries, and overall efficiency is correspondingly lower. As the dry season advances and water supplies dry up, stock have to walk farther each day to collect smaller amounts of herbage, until a point is reached when energy expenditure exceeds intake, and liveweight losses occur. Apart from the advantages of small size in reducing basal metabolic needs, two small animals can be in two places and have a greater opportunity of finding and eating more food per day. Consequently, they have a better chance of surviving and reproducing than a single large animal with a higher potential productive capacity [3].

Livestock Improvement

Livestock improvement in tropical and sub-tropical environments differs in an essential manner from improvement in temperate regions. In the latter, selection is on appetite and the ability to consume large quantities of nutritious foodstuffs. In arid sub-tropical areas, selection must remain on ability to extract the maximum nutrients from limited amounts of foodstuffs. It is obvious, therefore, that standards of efficiency will differ between intensive European and extensive East African conditions. When temperate animals, bred for efficient physiological functioning at high levels of nutrition, are brought into tropical or sub-tropical environments containing limited foodstuffs they are immediately at a disadvantage. There is, in fact, a close relationship between heat tolerance and the growth, productive, and fertility rates of cattle, whilst the poor adaptability of temperate breeds to high temperatures markedly reduces their efficiency of foodstuff utilization and their outputs of human food [4].

Programmes of livestock improvement aim at developing strains with higher productive powers and the subsequent distribution of their progeny through African areas. Increased hereditary productive potential inevitably requires a higher plane of nutrition, and all breeding programmes need constant review to ensure that potential production does not outstrip improvements in nutrition and management which are feasible physically and practically. Improvement measures must produce livestock which will survive, reproduce, and provide food for their offspring and owners on the nutritional levels in the environments in which they are expected to live [5]. Only in a limited number of localities are suitable environmental and nutritional conditions found, within sufficiently easy access of a consuming market, to justify concentrating exclusively on milk production. Over most of East Africa the need is for less productive cows which are able to rear their calves well and provide milk for their owners, which will produce superior meat-producing male stock, and which will yield reasonable carcasses when their productive lives are over. In the more remote and in the semi-arid regions, where little is now expected from the flocks and herds beyond maintaining their numbers, providing blood, milk, and occasionally meat for their owners, schemes for increased meat production must envisage the more efficient utilization of the herbage. Increased output of human food from these areas is closely associated with education of the people and the need to introduce a stratification of animal industry within East Africa. The breeding of stock in one area, rearing as "stores" in another, and their final fattening in a third district, is well recognized in other parts of the world and a similar stratification must ultimately be developed in East Africa. The remote semi-desert areas could then be used to breed yearlings, which could grow out in a slightly higher nutritional environment and finally be sold for fattening in the better areas. This would remove the need for keeping so many breeding stock and would permit a larger turnover of meat animals in the better areas, whilst the semi-desert areas would be more efficiently used for the only purpose for which they are now suitable—maintenance and reproduction—as they would no longer be required to carry unnecessary large numbers of mature slaughterable animals. A further advantage of this would be the steady movement of stock to the consuming centres whilst they were still growing, instead of the long treks, with the consequent loss of weight and deterioration in condition, to which mature stock are often subjected immediately before slaughter.

Since meat from local cattle is inferior to that from temperate climates in tenderness, vitamin B_1 content, finish, degree of "marbling" and flavour, and in view of the low efficiency with which animal feedingstuffs are converted into meat, it may be wondered why so much emphasis is placed on meat production. It is

because of the great sociological and educational obstacles which must be overcome before intensive production of human food is possible on a large scale, and because of the time lag inevitable in surmounting these difficulties. The need for animal proteins is so great that, within the environmental and nutritional conditions and the alterations in African practices which appear possible in the foreseeable future, the only practical development is to build existing and known methods of African husbandry into the stratification of meat production, along the lines already indicated, and to develop dual-purpose animals in the better areas. Dairying in African hands is, and will remain, restricted to favoured localities. With dual-purpose stock, butterfat from surplus milk can be stored or sold, provided the non-fatty portion of the milk is fully utilized. Any system of farming which relies on the production and marketing of butterfat, without fully utilizing the separated milk, exists on a very low level of efficiency of foodstuff utilization, because the fat-producing efficiency of 2-gallon cows is only 6.5 per cent.

Tenderness, flavour and marbling of beef from Zebu animals can be improved only by raising the nutritional levels and reducing the time to reach slaughter weight. A meal of tough meat, however, is far better than no meat at all. Tenderness and a high degree of finish, as such, are not essential nutritionally and are of less immediate importance than the need to increase the total output.

Livestock Feeds

European colonists brought to East Africa many of their traditional customs, amongst which was the feeding of cereals and other concentrated foodstuffs to livestock to improve productivity. Such foodstuffs are essential for intensive pig and poultry production and are a convenient means of providing the extra nutrients required by high-producing cows. Such a practice increases the competition between man and his livestock for foodstuffs common to both. Owing to the low efficiency of utilizing foodstuffs by stock, cereals will provide man with more energy, when consumed as such, than after conversion into another edible form even though the latter has a higher biological value. This means that, in the overall policy, all cereals and edible concentrated foods should be reserved for consumption by man, whilst surplus supplies should be converted into other human foods by pigs and poultry. Ruminants should be expected to make the maximum use of crop residues and such concentrated foods as are unattractive to or inedible by man, and to rely mainly on natural grazings, browse plants and any other roughages they can scavenge. Because of the relative abundance of fibrous fodders in East Africa and the scarcity of concentrated foods, ruminants are and will remain the most important of domestic livestock [6].

Grass is the only single foodstuff on which domestic herbivora can be maintained in health indefinitely. It therefore comes as a shock to most people to learn that more animals feed on shrubs and trees, or on plant associations in which they form an important part, than on true grass pastures [7]. Consequently, no programme of improved meat production can afford to neglect the use of mineral-rich browse plants. Grass pastures, when environmental conditions permit, yield larger quantities of animal nutrients than natural bush grazings but, over much of East Africa, their yields are restricted by the length of the growing season. Much could, however, be done to improve herbage yields by extending the period of grazing by browsing and by conserving the the surplus fodders produced at the peak periods of growth. The difficulties of getting conservation measures adopted in African areas are fully appreciated, but it is considered that this must be done.

The annually recurring spectacles of dried-up grazings, of overstocking leading to destruction of the vegetational cover, and to soil erosion, and of the hundreds of thousands of animal deaths from starvation, when considered alongside the equally distressing destruction of thousands of acres of grazings by fire, should provide ample justification of the necessity for fodder conservation. It is, perhaps, just as well that we do not know the numbers of animals which could be saved from starvation deaths, the total liveweight losses which could be prevented, and the quantities of meat and milk which could have been produced from fire-destroyed herbage each year. Serious as this thought may be, it is even worse to realize that, even on the unburnt grazing areas, large quantities of badly needed herbage nutrients are annually lost to the livestock industry through man's failure to harvest them.

Young green grass is a highly nutritious foodstuff but its value decreases rapidly as it matures. Every year large quantities of grass

nutrients appear and every year a high percentage are lost to grazing animals through the changes that accompany maturity. It is sometimes suggested that, in East Africa, grasses can be allowed to dry off and be converted into hay *in situ* and later be collected and eaten by grazing animals. It has been conclusively shown [8] that the feeding values of mature green grass and "standing hays" are much lower than if the crop had been utilized or harvested earlier when the flowering heads were emerging. With increasing maturity there is an increase in lignification, a lowering of the general organic matter digestibility, and a reduction in the percentage utilization of digested nutrients by the animal body whilst, if the herbage is left uncut, there is also a migration of mineral matter to the roots. Conservation of grass at a stage which will preserve the optimum quantities of nutrients, for dry-season use, is the most practical method of increasing the yield of human foods of animal origin.

Because of lack of conservation, liveweight losses of oxen may exceed 1 cwt. per dry season, with average losses of between 25 lb. and 60 lb. in cattle with a mean liveweight of 500–600 lb. [9]. Such losses occur over vast areas of East Africa and it can be calculated that, with an average dry-season loss in weight of 28 lb. per head, not less than 24,000,000 lb. of edible beef is lost to the African community every year through failure to conserve grass. This is not all, because the loss in immature stock has to be regained the following season before any net liveweight gains can be made. The weight loss in pregnant females has an adverse effect on the milk supply in the succeeding lactation, and in lactating cows it hastens the cessation of milk secretion.

When these weight losses were recorded, it was shown that if oxen, which lost 50 lb. in weight during the dry season when consuming mature herbage dried off *in situ*, had eaten the same quantity of the same herbage made into hay one month after the end of the rainy season, their weight losses would have been halved. If the herbage had been made into hay at the end of the rains, gains and not losses would have resulted. On the basis of the same figures, it was calculated that Zebu cattle could reach slaughter weight at least three years sooner if grazings were made into hay at the end of the wet season. Expressed differently, this means that existing grazed areas could carry 25–35 per cent more cattle to present slaughter weights and yield more tender meat. Similarly, it can be calculated that, without any change in stock numbers, the potential milk yields could be raised by 40–100 gallons per cow. Once conservation can be introduced, it is obvious that there would be a possibility of raising the average *per capita* milk consumption to a quarter-pint per day, although the supply would not be evenly distributed. The consumption of milk would still be below normal recommended standards but could alleviate the worst effects of protein shortages in African diets.

Conservation of Grass

Haymaking is the oldest method for preserving grass nutrients although the quality can be seriously reduced by wet weather. It is for this reason that, in the previous remarks, calculations were made with hay made after the rains had ceased. The curing of hay on simply constructed racks not only reduces the spoilage by rain but greatly reduces leaf losses and preserves a high percentage of the carotene content. In order to make the conservation process less dependent on weather conditions, grass could be preserved by ensiling in pits. This process may well prove the more popular because conservation would take place in the rainy season and permit the better growth of aftermath grazing.

Undulating liveweights resulting from alternate periods of nutritious wet-season grazing with sub-maintenance dry-season subsistence are not only distressing to observe but seriously reduce the economy and the efficiency of human food production from local grazings. The dry-season shortages divert, to non-productive maintenance purposes, a high percentage of nutrients which could be used for producing human foods. Under such conditions there is a strong natural selection to eliminate high-producing stock and to encourage the survival of those which are less productive [10].

African-owned stock suffer as much from shortages of water as from any other deficiency. Water shortage reduces milk yields and can seriously reduce productivity if animals have to walk long distances to drink. Inadequate and badly distributed water supplies inevitably cause certain areas to be overstocked and others to be under-grazed. Low intakes can affect rumination and impede digestion so that the efficiency of food utilization can be reduced. The essential role of

water in the heat-regulating mechanism of cattle is probably connected with the greater water requirements of less heat-tolerant animals and the ability of Zebu stock to exist for weeks or months when watered only every third day.

MINERALS, AMINO-ACIDS, AND B-VITAMINS

Popular imagination is often fired by the spectacular results reported from other countries when mineral deficiencies are corrected, but the amelioration of such deficiencies as have been suspected or proved in East Africa, has not revolutionized African husbandry practices nor the production of human foods. Local mineral deficiencies are generally secondary to the absolute shortage of foodstuffs and will probably not become limiting factors, except in restricted localities, until there is no quantitative lack of foodstuffs. By this it is not meant to imply that, in the meantime, shortages of certain elements, such as phosphorus, will not depress appetite, food utilization and productivity, but rather to suggest that mineral deficiency studies will be easier to interpret and become of greater economic significance once the gross shortages of proteins and energy have been removed.

In human nutrition, the importance of certain amino-acids, which the body does not synthesize, are well known. Shortages of the same essential amino-acids in the diet of pigs and poultry can seriously reduce the efficiency of feed utilization, but ruminants are less dependent on pre-formed supplies. This is because of extensive microbial synthesis in the rumen, followed by the rupture and disintegration of the bacteria and the digestion and absorption of their proteins farther down the alimentary tract. The same symbiotic arrangement normally enables ruminants to be independent of the vitamins B in their foodstuffs.

It is felt that sufficient care is not always devoted to providing complete rations for non-ruminants under intensive conditions, and that some of the reduced growth rates, poor muscular development and low feed-conversion rates may be due to deficiencies of specific amino-acids. Similarly, it is thought that sub-clinical B-avitaminoses occur and are responsible for sub-optimal productivity such as low nitrogen retention in growing pigs or the low hatchability of eggs at high altitudes. In the case of ruminants, it is thought that, under East African conditions, there is a too ready acceptance of their ability to obtain, from rumenal microbial synthesis all their amino-acid and vitamin needs. Bacterial metabolism and growth depend on the substrate and it has not yet been proved to what extent the dried, fibrous, low protein and mineral containing dry-season fodders provide for a sufficiently rapid bacterial growth to enable essential amino-acids and B vitamins to be absorbed at the necessary rates. It has been shown that the rumenal bacterial population varies with the nature of the diet and that, with highly fibrous dry fodders, the rate of passage through the rumen is retarded [3]. With such suggestive evidence of reduced bacterial activity with dry-season fodders and the probability of alterations in the microbial population, it is but a short step to speculate whether possible sub-clinical deficiencies may not be interfering with physiological and metabolic process in cattle during the dry season.

Endocrinology and nutrition are intimately co-ordinated in the production of human foods from livestock. Blood-circulating hormones stimulate mammary development in late pregnancy but the effect is conditioned by the nutritional plane. Neither the presence of sufficient nutrients nor of the necessary quantity of hormone are fully effective in the absence of the other component. The rate of reproduction is of fundamental importance in economical animal production and both hormones and nutrients are closely associated in the efficiency of this process. A common defect of local cattle is their reluctance to "let-down" their milk. Overseas studies suggest that, because milk pressure in the udder retards secretion and hastens its cessation, there are possibilities of increasing milk output either by more frequent milkings or by breeding for greater elasticity in udder tissue [11].

NUTRITION AND BREEDING

By selection and breeding it is possible to improve the "letting-down" of milk and the yields, and the Livestock Centres have shown that it is fairly easy to obtain herd averages of 200 gallons from "milked-out" cows but that further improvements in yield are more slowly achieved. On one centre, a herd average of 290 gallons has been reached with indigenous cattle and two proven strains have been established. The output of human food can therefore be considerably increased above that of average African herds, but it has not been generally established what proportion of the

potential increase is due to genetics and what to improved management and feeding. It is probable that a high proportion of the early increases in yields is due to environment, and that genetic improvement is more important in the later and slower increases [12].

It is occasionally suggested that animal productivity can be rapidly improved by suitable breeding. Whilst the development of genotypically superior strains is absolutely essential, it is important to realize that the rate of genetic improvement cannot be rapid. The low heritability and the polygenic nature of the productive characters in domestic livestock suggest that the greatest increases in these characters will, for many years, come from improvements in feeding and management, especially as, by the time a suitable genotype has been identified, its period of active reproduction is severely limited by age. A further obstacle to rapid genetic improvement of African stock is the system of communal grazing and the impossibility of preventing females being mated indiscriminately with unimproved males.

Early attempts to improve indigenous stock sought to increase productivity and rate of maturation by crossing with improved exotic breeds. The severe limitations of the local environment and the impossibility of improving livestock efficiency without corresponding improvements in nutrition and management were soon discovered. At the same time, it was discovered that Zebu cattle, in the local environment, were superior to temperate breeds in their heat-tolerating powers, resistance to certain diseases, ability to walk long distances and to exist on low water intakes [10]. In pure and high-grade European cattle, the failure of their heat-regulating mechanism causes considerable physiological stress, reduced appetite, and low productivity, and leads to constitutional breakdowns which make them less economic and productive than indigenous animals where air temperatures are above 70° F. The possibility of improving the output of human food from African-owned stock by crossing them with European breeds generally offers little hope of success. More recent attempts to cross local stock with comparable, but improved, Zebus from India and Pakistan are more promising but, over much of East Africa, genetic improvement will be confined to the slower method of selection and breeding within local Zebu types.

Meat Production

As an animal matures it not only increases in weight but undergoes corresponding changes in conformation and in the relative proportions of the different organs, tissues and joints. The liveweight changes, with age, follow a sigmoid curve and the period of maximum growth rate is important economically because it determines the time of most profitable and most efficient growth. The changes which occur in the relative proportions of the body vary between strains and species, with the plane of nutrition and with the object for which the animals are reared. They are caused by the different parts of the body growing at different rates and, in general terms, a wave of growth starts at the head and passes down the trunk, whilst secondary waves, starting at the extremities, pass inwards and all meet in the loin. The loin is thus the last part of the body to develop to maturity. Growth gradients also exist within the joints and the order is bone, muscle and then fat. Obviously, the meat-producing value of an animal depends on the rate and extent of these developments, and selection for genetic improvement depends on the identification of those animals which pass through the age changes most quickly when reared on a nutritional level which will permit their full development. Improved meat breeds reach, at an early age, a body conformation and the development proportions which are attained by unimproved breeds only at maturity [13].

Since the percentage of edible meat in the total liveweight increases as mature proportions are reached in the relative development of the different joints and tissues, early maturity plays an important part in the efficiency of meat production. It is easier to achieve in small than in large breeds and, to obtain good carcasses with desirable amounts of muscle and fat suitably distributed, the right breed has to be properly fed. In fact, by varying the plane of nutrition at different stages of growth, it is possible to alter the proportions of muscle, fat and bone in the different parts of the body [14]. On low planes, the earlier developing maintenance organs and the skeleton have first call on available nutrients and the development of the later-maturing loin, muscle and fat is retarded. Animals reared on a low nutritional plane have high percentages of bone and low percentages of edible meat of low calorific value. Conversely, on a high nutritional level, growth

of the later-developing muscle and fat can be made to occur before the bone-development phase has ceased. If an animal is reared first on a high and later on a low plane of nutrition, its frame and muscular tissues are well developed, but later development is proportionately retarded and carcasses containing a high proportion of lean to fat are obtained. If, however, the animal is badly fed in early but well fed later in life, the early stunting results in reduced skeletal and muscle development whilst the later-developing parts are unaffected. This produces a carcass containing too much fat in proportion to lean meat [15].

In efficiency of feed utilization, underfeeding in early life, followed by a high level of nutrition, is the most wasteful, and no matter how well one may feed an animal, stunted throughout its early life, one can never achieve the efficiency of food utilization nor the desirable muscle:fat ratio which the animal was genetically capable of attaining. On the other hand, efficient feed utilization and desirable carcass proportions are possible, in spite of temporary food shortages, provided the animals have been well fed during early life. This points the way to better meat production in East Africa and emphasizes the overriding need to improve the feeding and management of young stock to levels which so far have not been contemplated in African systems of animal husbandry.

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MAIZE-GROWING AT ISMANI, IRINGA, TANGANYIKA

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Celestino Fivawo stands head and shoulders above his Hehe neighbours as a farmer, both for his energy and his intelligence. Until 1949, he farmed at Kiponzelo, near Iringa, but had come to realize that he could never rise much above subsistence level on its over-cultivated and eroded soils, where satisfactory crops can be harvested only if the land is heavily manured and if the rains are good. Celestino, therefore, began a search for new land on which to grow maize on a big scale.

It is difficult to find any unoccupied good land near Iringa, but Celestino found what he wanted at Ismani, rolling country lying along the Great North Road from 14 to 29 miles north of Iringa. The soils are fairly fertile, red, sandy loams derived from granite. The rainfall of 20 inches to 25 inches a year, unless it is well distributed, is low for maize. Ismani had been left virtually unused because there is no surface water during most of the year, and it is covered with a low scrub or thicket so dense as to deter most people from attempting to clear it.

When the permission of the local sub-chief had been obtained, Celestino, with others whom he had persuaded to join in the venture, paid labour to clear the thicket during the dry season. The bush was merely slashed near ground-level and left to dry as it stood, for it was usually too intertangled to fall. Just before the rains, it was fired and burned so fiercely that all the cut bush was destroyed, many of the stumps were killed and in places fire spread to the uncut bush. At, or just before the first rains, maize was broadcast in the ash of the fire, and no cultivation whatsoever was done except perhaps to slash bush sprouts and any weeds whose roots or seed had survived the fire. There was little time for the ash to be blown away before the rains came, and the stumps and uncut bush gave some protection against the wind. All through the first dry season, domestic water was transported on lorries from Iringa by the farmers themselves or by contractors.

In the second year, Celestino and his neighbours cleared more bush by the same method, and again grew maize in the ash without cultivation. In the land cropped the year before, they slashed any weeds and regenerating bush and burned them with the dry maize stalks. They did no cultivation, apart from making hoe marks at yard intervals, putting two or three seeds into each hole and covering them with earth by a movement of the foot. Some weeding had to be done, but this was as sketchy and as late as possible. Rather to the surprise of the Agricultural Department staff, the maize that was left unweeded until the weeds were about a foot high looked better than the early weeded crop. Perhaps in the Ismani conditions, protection from sun and wind is more important than the absence of competition for soil moisture.

During 1950 and 1951, more and more people cleared land in the area and grew maize, using Celestino's methods. Some remained as residents, for Celestino built a dam which caught the flood water in a little valley. Those who had laboured for him to make the dam could get their domestic water from there. The others still brought it in from Iringa. The influx of cultivators continued into 1952 and 1953, and the area under maize increased rapidly. Returns of maize deliveries from Ismani to Messrs. Unga, Ltd., in Iringa illustrate this increase, though it is known that very many unrecorded sales were made in Dodoma, Iringa and elsewhere:—

1949—no separate records kept.
1950—500 tons.
1951—1,800 tons.
1952—4,000 tons.
1953—511 tons (a drought year).

There is no record of the total number of people cultivating in Ismani, but there were 500 resident taxpayers in 1952.

Several factors have contributed to the rise of Ismani as a maize-producing area. The price of maize in Iringa rose from Sh. 16 in 1949 to Sh. 31/47 in 1953 per 200 lb. delivered in 3-ton lots, and this induced Africans to grow maize as a cash crop. Ismani lies along the main road and many Iringa Africans owned lorries which they used to carry water, labour, and maize between the two places. The main attractions were the sight of big crops of maize, produced with so little arduous work, and rumours of enormous profits made.

Yields were estimated as up to 20 bags per acre. Celestino sold his maize in 1952 for £3,000, another man sold his for £2,500, and several others were in the £1,000 class. No records of expenditure exist, but it is guessed that at least half of these figures was clear profit. Many of the growers lost their wealth as quickly as they had gained it, but some have bought lorries, tractors, and implements, and are planning for still bigger production, despite the failure of the 1953 crop.

Many of the pioneers abandoned the land to bush and weed fallow after two years' cropping, and burned further tracts of bush. They considered that slashing and burning the bush was less arduous work than the cultivation and weeding of their big areas (some had over 100 acres under maize), especially as the remaining stumps and roots restricted the use of ploughs. The used land was, however, often cropped again by the original occupiers or by newcomers, and it was in this land that the first signs of erosion appeared. The recognized system of African cultivation in the Iringa Highlands is the "Hehe Ridge" which has much to commend it as a conserver of humus and as an erosion control. This is similar to the ridges described in this *Journal* [1]. In Ismani, the individual holdings were usually too big to be cultivated in this way and, besides, many of the maize growers are shopkeepers, lorry drivers, and mechanics, from many tribes, unaccustomed to ridge cultivation. The land in its third and subsequent years was either hoed or ploughed on the flat, leaving it very susceptible to erosion.

Naturally the spectacular expansion of Ismani has been carefully watched by those responsible for the welfare of the land and its people. It is estimated that by 1953 there were 15 square miles of former bush-land under maize. The problem is how to keep the land productive. With careful handling, the soil could continue to produce good crops, except in drought years, but there is a grave danger that it may suffer from monoculture, overcropping, and erosion. Cattle are beginning to be brought into the area, and stable mixed farming is being encouraged to replace maize alone. The Agricultural Department has supervised the building of a dam, and others are to be made. There are signs that people at Ismani wish to settle permanently and they have formed a Co-operative Society to sell their maize to the best advantage.

In 1951, a conference of the Native Authority, Provincial Administration and Natural Resources Departments, met to investigate the problems of Ismani and to control its further development. Regulations were prepared limiting the size of individual holdings, enforcing ridge-cultivation or contour banks, insisting on adequate fallows, and the planting of beans and other crops, not maize alone.

Some progress towards better farming has been made, though the regulations are difficult to enforce as many of the users of the land are non-resident and do not come under the jurisdiction of the Ismani sub-chief; many are from outside tribes having no tradition of loyalty to the local chief, and many are interested only in the quick money to be made, not in the continued fertility of the land. It remains to be seen whether Ismani, which has been virtually useless thicket and then highly productive maize-land will revert to infertile and eroded bush-land, or whether it can be made an area of stable mixed farming with continued productivity. If this can be achieved, then Celestino's methods may be the simplest and most economical method of converting many other similar bush areas of East Africa into useful farm land.

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E.A. MILK RECORDS OF LEADING COWS—JANUARY TO JUNE, 1954

By the East Africa Milk Recording Scheme, P.O. Box 478, Nakuru, Kenya

CLASS 1 (UNDER 2 YEARS OLD)

Name and Address of Owner	Name of Cow and Sire	Breed	Date of Birth	Lactation Records: No. of Lactation	Calving Dates	Milk Yield (lb.)	Days	B.F. %	B.F. (lb.)
1	2	3	4	5	6	7	8	9	10
Gendin Farm, Ltd., Nakuru	Gendin Magpie, G.B.89, *Kerse Park Chosen Crown.*	Ayrshire P.	25–1–51	1st	18–12–52	5,334·75	305	4·21	224·59
Mrs. Isabel Clarke, Nyeri ..	Nyeri Lady Joyful, *Chettles Gay Laddie.*	Guernsey P.	4–10–50	1st	4–8–52	5,095·75	305	5·23	266·52
M. A. U. Heathcote, Kitale ..	Kiss Me Kate, *Dreaming Maryer* 8189.	Jersey P.	24–7–51	1st	26–4–53	5,652·50	289	4·84	273·58
Lt.-Col. R. D. Gordon, Ol' Joro'Orok.	Ndare Shelagh, *Unknown.*	„ N.P.	20–6–51	1st	31–5–53	5,368·80	305	5·78	310·32

CLASS 2 (UNDER 2½ YEARS OLD)

Name and Address of Owner	Name of Cow and Sire	Breed	Date of Birth	No. of Lactation	Calving Dates	Milk Yield (lb.)	Days	B.F. %	B.F. (lb.)
Mtarakwa, Ltd., S. Kinangop	Mtarakwa Witch 2nd, *Benmore Yeoman.*	Ayrshire P.	2–8–50	1st	11–2–53	8,576·10	291	4·20	360·20
Hafod Estates, Ltd., Limuru	Stella 2nd, *Mtarakwa Baronet.*	„ N.P.	12–10–50	1st	4–12–52	10,182·75	305	3·13	318·72
B. R. McKenzie, Nakuru ..	Gingalili Orris 1569, *Rutje's Eduard 3rd.*	Friesland P.	8–10–50	1st	6–1–53	9,840·80	305	3·57	351·32
Pease Estates, Ltd., Njoro ..	No. 530, *Wellmirlic.*	„ N.P.	15–10–50	1st	3–2–53	4,554·00	305	4·71	214·49
Blundell Estates, Ltd., Nakuru	Goldie's Dairymaid 5th of Claverham *Lenita's Dairyman of Les Fontaines.*	Guernsey P.	14–5–50	1st	31–10–52	9,196·40	305	4·68	430·39
S. S. Bastard, Sotik	Bisiot 3rd 189, *Primrosies Countryman of Rail.*	„ N.P.	4–2–51	1st	10–5–53	6,949·00	305	4·15	288·38
Osirua Jerseys, Limuru ..	Brumide, *Origa's Bright Star.*	Jersey P.	21–3–51	1st	12–5–53	5,808·50	295	5·57	323·53
D. E. Fielden, Nakuru ..	Bamba VIII 302, *Melpomene's Dreamer.*	„ N.P.	17–7–50	1st	13–12–52	7,710·40	262	5·38	414·82

P.—Pedigree. N.P.—Non-Pedigree.

CLASS 3 (UNDER 3 YEARS OLD)

Name and Address of Owner	Name of Cow and Sire	Breed	Date of Birth	Lactation Records: No. of Lactation	Calving Dates	Milk Yield (lb.)	Days	B.F. %	B.F. (lb.)
1	2	3	4	5	6	7	8	9	10
G. S. Ransom, Kiambu	Mtarakwa Willow 4th *Benmore Quixote.*	Ayrshire P.	31–7–50	1st	14–3–53	8,028·50	299	3·88	311·51
Lesirko, Ltd., Ol'Kalou	Lesirko 907, *Denbigh Punch.*	" N.P.	25–4–50	1st	23–1–53	7,830·10	294	4·13	323·38
B. R. McKenzie, Nakuru	Gingalili Loyalty 1547, *Rutje's Eduard 3rd.*	Friesland P.	9–9–50	1st	10–5–53	6,699·30	228	3·88	259·93
Wolstaston Estate, Menengai	England 68 of O., *Grade.*	" N.P.	11–5–50	1st	28–1–53	7,921·80	305	3·08	243·99
Coull Farm, Nakuru	Coull Sunshine 1st. No. 163, *Caradoc Tarragon'*	Guernsey P.	28–8–50	1st	17–3–53	4,807·00	287	5·39	259·10
Rhodora Estates, Ltd., Nakuru	Rumaval 2nd, B.32, *White Ladies Champion 8th.*	" N.P.	14–9–50	1st	7–6–53	5,801·10	305	4·73	274·39
Major & Mrs. L. B. L. Hughes, South Kinangop.	Hathor Arabella, *Bluebeard of Rosel.*	Jersey P.	3–2–50	1st	26–12–52	6,502·20	304	5·55	360·87
P. N. Dearlove & A. Jowitt, Ainabkoi.	Chemati G.20, *Lynmouth Noreen's.*	" N.P.	27–1–50	1st	10–11–52	6,298·00	305	6·02	379·14
H. C. Coltart, Njoro	Tanner 112. *Unknown.*	Red Poll N.P.	Unknown	1st	2–5–53	5,874·00	297	5·00	293·70

CLASS 4 (UNDER 4 YEARS OLD)

Name and Address of Owner	Name of Cow and Sire	Breed	Date of Birth	No. of Lactation	Calving Dates	Milk Yield (lb.)	Days	B.F. %	B.F. (lb.)
Schiehallion, Ltd., N. Kinangop.	Kibsworthy Matilda, *Eglinton Mains Baronet.*	Ayrshire P.	1–10–49	1st 2nd	1–8–51 4–12–52	6,457·00 10,298·05	305 305	4·65 4·29	300·25 441·79
Lesirko, Ltd., Ol'Kalou	Lesirko 901, *Hobsland Golden Arrow.*	" N.P.	3–12–49	1st	18–7–53	5,896·10	252	5·70	336·08
B. R. McKenzie, Nakuru	Karirana Godetia 1367, *Oldambtster Gysbrecht.*	Friesland P.	10–5–49	1st 2nd	16–4–52 14–3–53	8,066·80 8,856·30	273 277	4·01 3·97	323·47 351·60
B. R. McKenzie, Nakuru	Rita, *Unknown.*	" N.P.	28–2–50	1st	1–3–53	9,154·80	305	3·53	323·16
Blundell Estates, Ltd., Nakuru	Beaurepaire Princess Polly 9th, *Le Hamel Meteor.*	Guernsey P.	29–12–48	1st 2nd	12–11–51 19–11–52	10,563·80 11,333·00	310 305	4·55 4·21	480·65 477·14
Blundell Estates, Ltd., Nakuru	Menengai 4th, *Fernhill Roberts Lad 10th.*	" N.P.	21–5–49	1st	28–1–53	8,000·60	305	4·57	365·63
Roderick Lea, Ltd., Limuru	Mornmoot Fame 5th, *Mornmoot Fancy Baron.*	Jersey P.	30–7–49	1st	14–12–52	7,057·50	303	5·89	415·69
D. E. Fielden, Nakuru	Laia 4, 258, *Osirua Jupiter.*	" N.P.	14–10–49	1st	17–2–53	5,669·60	305	6·85	388·37
H. C. Coltart, Njoro	Zomba 313, *March Peregrine.*	Red Poll N.P.	19–7–49	1st	13–1–53	7,472·00	302	3·51	262·27

P.—Pedigree. N.P.—Non-Pedigree.

CLASS 5 (UNDER 5 YEARS OLD)

Name and Address of Owner	Name of Cow and Sire	Breed	Date of Birth	Lactation Records: No. of Lactation	Calving Dates	Milk Yield (lb.)	Days	B.F. %	B.F. (lb.)
1	2	3	4	5	6	7	8	9	10
Miss M. E. B. Atkinson, Limuru.	Preston Floralin, *Bargower Model.*	Ayrshire P.	12–12–48	1st	25–12–52	9,299·38	305	4·00	371·98
				2nd	3–2–53	9,600·40	305	4·25	408·02
D. Furze, Nakuru	Susie, *Carnell Man O'War.*	,, N.P.	17–6–49	1st	23–6–51	7,845·75	283	3·56	279·31
				2nd	5–7–52	8,192·50	276	3·52	288·38
				3rd	29–6–53	8,409·25	305	3·92	329·64
B. R. McKenzie, Nakuru ..	Genstuart N. V. Ailsa, *Glenstuart Netherland Victory.*	Friesland P.	12–10–48	1st	4–5–51	15,238·40	305	3·60	548·58
				2nd	4–2–53	17,913·80	299	3·96	709·39
Wolstaston Estate, Menengai	Morijo 53 of 8, *Unknown.*	,, N.P.	5–4–48	1st	24–2–52	8,086·40	283	3·65	295·15
				2nd	16–3–53	9,048·60	301	3·59	324·84
Rhodora Estates, Ltd., Nakuru	Rex's Rose 6th of Pay Hay, *Fernhill Robert's Lad 6th.*	Guernsey P.	9–9–48	1st	29–11–50	8,187·40	307	4·50	368·43
				2nd	14–1–52	9,595·10	302	4·32	414·50
				3rd	26–1–53	10,199·10	305	4·75	484·46
S. S. Bastard, Sotik	Mororochi 136, *Unknown.*	,, N.P.	15–9–48	1st	21–12–50	8,053·00	305	3·45	277·83
				2nd	25–4–52	9,690·60	265	4·00	387·62
				3rd	5–3–53	9,704·70	305	4·04	392·07
R. A. Clay, Elburgon ..	Favorite of Brook Farm, *Sybil's Junior.*	Jersey P.	4–3–48	1st	26–8–50	11,332·75	340	5·00	566·64
				2nd	19–9–51	7,064·50	287	5·69	401·97
				3rd	25–12–52	10,905·45	305	4·69	511·47
R. A. Clay, Elburgon ..	Maharajah's Eve II, *Maharajah of La Commune.*	,, N.P.	11–6–48	1st	26–9–50	5,733·75	253	5·04	288·98
				2nd	18–9–51	9,991·80	305	5·34	533·56
				3rd	29–10–52	9,031·30	305	5·14	464·21
S. V. Aitchison, Ol'Kalou ..	D'ragwa, *Flaxlands Norfolk.*	Red Poll N.P.	25–9–48	1st	27–2–51	3,260·50	216	5·06	164·98
				2nd	2–1–52	4,041·50	261	4·64	187·53
				3rd	24–2–53	3,889·70	228	5·38	209·27

P.—Pedigree. N.P.—Non-Pedigree.

CLASS 6 (MATURE)

Name and Address of Owner	Name of Cow and Sire	Breed	Date of Birth	Lactation Records: No. of Lactation	Calving Dates	Milk Yield (lb.)	Days	B.F. %	B.F. (lb.)
1	2	3	4	5	6	7	8	9	10
Mtarakwa, Ltd., S. Kinangop	Mtarakwa Maude 3rd, *Benmore Yeoman 960.*	Ayrshire P.	5–12–45	1st	3–6–49	9,340·90	303	4·66	435·36
				2nd	9–7–50	9,598·10	309	4·88	468·39
				3rd	18–8–51	12,319·00	305	4·04	497·69
				4th	19–12–52	12,008·10	305	4·45	534·36
						Gall.			
J. L. Downey, Limuru ..	Square II, *Mtarakwa Masterpiece.*	Ayrshire N.P.	13–9–46	1st	2–2–49	839·6	271	Not Officially Recorded.	
				2nd	2–1–50	1,402·1	338		
				3rd	26–2–51	1,521·6	355		
				4th	3–3–52	837·9*	301		
						Lb.			
B. R. McKenzie, Nakuru ..	Karirana Moonstone, *Kipipiri Staton.*	Friesland P.	19–7–43	5th	23–6–53	19,767·85	305	4·22	834·20
				1st	17–11–49	19,029·10	248	2·83	538·52
				2nd	26–2–51	21,980·60	365	2·85	636·45
				3rd	6–12–52	16,548·10	305	2·73	451·76
Manera Farm, Naivasha ..	X.104, *Unknown.*	,, N.P.	Unknown	1st	27–2–51	17,144·00	365	2·72	466·32
				2nd	29–3–52	7,649·00	305	2·95	225·65
				3rd	28–3–53	14,713·50	297	3·03	445·82
Olbonata, Ltd., Nakuru ..	Olbonata Sundew, *Ruth's Hero of Whiston.*	Guernsey P.	23–8–47	1st	11–11–50	7,060·90	297	5·27	372·11
				2nd	17–11–51	8,276·20	305	5·28	436·98
				3rd	29–1–53	8,742·80	305	5·06	442·39
Coull Farm, Nakuru	Frinda I, 38, *Nderit Lavender's Tangerine.*	,, N.P.	19–6–41	1st	24–4–53	9,342·60	305	4·65	434·43
Mrs. W. S. Luke, Limuru ..	Osirua Successful Clover, *Osirua Wonderful Successor.*	Jersey P.	3–12–44	1st	14–12–52	11,220·10	305	4·80	538·56
D. E. Fielden, Nakuru ..	Jimma II, 116, *Hanteville Blonde Sultan.*	,, N.P.	22–10–45	1st	19–10–49	7,955·10	355	6.00	498·02
				2nd	11–12–50	6,317·40	234	5·84	368·94
				3rd	10–10–51	10,875·10	320	5·73	623·14
				4th	6–11–52	11,039·05	305	5·77	636·95
Kapsiliat Estate, Moiben ..	Knepp Beryl 43rd, *Knepp-Consul.*	Red Poll P.	17–1–48	1st	8–2–53	7,050·00	233	3·90	274·95
H. C. Coltart, Njoro	Kilango 236, *Unknown.*	,, N.P.	Unknown	1st	23–6–53	5,276·00	253	5·41	285·43

*Cow was ill for several months. P.—Pedigree. N.P.—Non-Pedigree.

SMALL-SCALE FISH MEAL PRODUCTION UNDER TROPICAL CONDITIONS

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At the present time there is a world shortage of protein which affects both the human population and its livestock. This shortage is very pronounced in Uganda, where the principal locally grown foodstuffs are of a starchy nature, and, since the intake of food by humans or animals is limited by bulk, these foods cannot supply sufficient proteins for normal requirements. Certain amounts of meat, fish, beans and groundnuts are consumed, but the supply is far below the need. There is, however, a considerable waste of protein-rich food from the fish industry, which consists of unsaleable fish and fish offals. The consumption of fish by the Uganda population is greatly influenced by taboo and local taste, and because of this the demand for various species of fish varies from one district to another. The climatic conditions and the difficulties of transport make the distribution of fresh fish expensive.

Fish and fish offals contain large amounts of high-quality proteins, and if suitably processed these could be utilized for both human and animal consumption. The dehydration of fish carried out in the United Kingdom and America during the war is a very expensive process, and to a lesser degree this also applies to the canning of fish. Both of these processes require highly skilled labour and expensive plants, while they only utilize high-grade material. The production of good-quality fish meal, however, is comparatively simple and can utilize either fish or offal [1].

There are two principal ways of making fish meal; these are by direct drying or by cooking before drying. The oil content of the raw material determines which of these two methods are to be used [2]. In Great Britain, where a very small proportion of oily material is used, the fish meal is made by the direct drying of fish as "White fish meal" using either batch or continuous driers, depending on the type and size of the plant [3].

In America and the Scandinavian countries, where there is a large proportion of oily fish offal, another method is used, the principle of which is to coagulate the proteins of fish, by cooking either in water or steam, and then to express the oil from the fish before drying. Some factories in Germany in their preparation of "White fish meal" prefer to cook the fish first and then press slightly before drying the product [4]: this is mostly done for economic reasons and also to obtain glue as a by-product. Stansby [5] found that raw fish could be dried at a rate approximately one-third that of cooked fish, and this resulted in a saving of fuel in drying cooked material. There are differences of opinion on the length of time and methods of cooking. Most commercial concerns dealing with oily fish are in favour of steam cooking, while Stansby recommends autoclaving for 7–10 minutes at a pressure of 5–10 pounds. The recommendation of Sparre [1] for small-scale manufacture of fish meal is to cook in water for 20–25 minutes or even longer. The time of cooking is of great importance [6] as the raw and insufficiently cooked fish takes longer to dry, and on the other hand prolonged pre-cooking lowers the quality of the product. There are also different views on the temperature of drying and the recommendations vary widely between different manufacturers, ranging from 130° F. to 240° F. It is obvious that drying at a high temperature would affect the quality of the proteins and the general appearance of the meal, while drying at too low a temperature might be uneconomical and might also affect the keeping qualities of the meal.

Investigations were carried out in this laboratory to solve these problems, and to find a method which would enable the small fishing centres to produce fish meal without involving any considerable initial capital or highly skilled labour.

A fish industry has been founded recently at Lake George with the main purpose of supplying whole fish and fillets. A certain amount of offal is available in the form of guts, heads and tails together with any fish which may not be easily marketed. This offal was used in the experiments, and in addition fish and fish offal were obtained from other lakes in the Protectorate.

METHODS OF PROCESSING

The following different ways of processing fish and fish offals were investigated:—

(1) Drying roughly chopped offal material by hot air current.

(2) Drying minced material by sun.

(3) Drying minced material by air current.

(4) Drying minced material by hot air current.

(5) Drying boiled, minced, and squeezed material by all the above methods.

(6) Drying minced, then boiled and squeezed material by hot air current.

(7) Drying minced then steamed and squeezed material by hot air current.

(8) Drying minced then autoclaved and squeezed material by hot air current.

PRELIMINARY INVESTIGATION

This investigation was carried out as a preliminary trial in order to obtain more information regarding possible techniques. The material consisted of mixed offals from various types of fish:—

(*a*) Offal was boiled for half an hour in a generous amount of water, then minced and dried. An attempt was made to dry by a forced unheated air current, but as this was unsuccessful it was abandoned after 24 hours and the drying was finished by heat. Since the cooked fish was not dry after 24 hours in an unheated air current, and it is an acknowledged fact that cooked fish dries quicker than raw fish, this technique was abandoned.

(*b*) Fish offals were dried for one hour at 100° C. and finished at 70° C. The material dried unequally, and in consequence the guts were scorched before the flesh and bones were dry. This method, although it could be used with offals containing flesh and bones only, does not seem to be suitable if guts are included. The oil content of the material is not altered by this process and this affects the keeping quality of the meal.

(*c*) The material was boiled for one hour with a small quantity of water; 250 ml. per 1 kg. of offal. It was then minced, squeezed and dried by hot air at a temperature of 70° C. This technique gave the most promising results, although the meal was far from being perfect. The percentage of oil left in the fish meal was 7.1 per cent which was considerably higher than in fish meal processed by method (*a*) (5.5 per cent). This suggested that the 250 c.c. of water per 1 kg. of offals used for cooking was not sufficient.

TABLE I—A COMPARISON OF METHODS USED IN PREPARING FISH MEAL

Methods	Dry Matter %	Total Ash %	Crude Oil %	Crude Protein %	NFE %	Time of Drying Hours	Vitamin B_{12} μg MBA /g
Sample 1, Fish, Boiled 15 minutes in two litres of water, Minced, Squeezed, Dried by hot air current	95·7	26·3	5·20	63·8	0·42	8·5	0·024
Sample 2, Fish, Boiled 30 minutes in two litres of water, Minced, Squeezed, Dried by hot air current	95·9	31·5	4·08	58·65	1·67	8·5	0·056
Sample 3, Fish, Boiled 45 minutes in two litres of water, Minced, Squeezed, Dried by hot air current	94·0	31·8	5·58	54·96	1·66	8·5	0·034
Sample 4, Fish, Boiled 60 minutes in two litres of water, Minced, Squeezed, Dried by hot air current	92·6	30·9	4·03	51·94	5·73	8·5	0·055
Sample 5, Fish, Boiled 30 minutes in 500 ml, of water, Minced, Squeezed, Dried by hot air current	96·4	29·5	5·82	59·02	4·06	8·5	0·038
Sample 6, Fish, Minced, Boiled 5 minutes in two litres of water, Dried by hot air current	94·2	28·3	4·81	58·48	2·61	8·5	0·345
Sample 7, Fish, Boiled 30 minutes in two litres of water, Minced, Squeezed, Dried by sun ..	92·3	26·6	4·0	61·0	1·74	10·0	—
Sample 8, Fish, Minced, Sun-dried	95·8	26·3	11·33	58·30	0·17	18·0	0·165
Sample 9, Fish, Minced, Dried by hot air current	94·3	24·1	12·30	56·76	1·11	20·0	0·24
Sample 10, Fish, Minced, Dried by hot air current	94·4	24·2	11·94	55·90	2·32	20·0	0·29

TABLE II.—A COMPARISON OF METHODS USED IN PREPARING FISH MEAL RESULTS EXPRESSED ON A DRY MATTER BASIS

Sample	Total Ash %	Crude Oil %	Crude Protein %	Total Yield of Proteins in gm.	Losses %
Sample 1	27.8	5.4	67.3	215	24.2
Sample 2	32.8	4.2	61.0	195	25.6
Sample 3	35.8	6.3	57.4	219	24.0
Sample 4	33.2	4.3	55.8	164	24.0
Sample 5	30.7	6.0	60.0	213	18.8
Sample 6	30.1	5.1	62.2	249	5.7
Sample 7	29.0	4.4	66.3	192	†
Sample 8	29.7	13.3	60.0	258*	†
Sample 9	25.6	13.5	60.2	252*	†
Sample 10	25.6	12.9	59.2	248*	†

*Standard Error, 4%. †Assumed to be none.

As this method of preparing fish meal by cooking showed the most promising results, the main investigation was planned to improve this technique and to compare the product with directly dried material. It was observed in the previous investigation that the presence of guts was interfering with the accuracy of sampling, and the chemical analysis which has been carried out separately on guts proved that there is not any considerable difference in the oil content of guts and the rest of the offals. Therefore in the main investigation the guts were omitted and only heads and tails were used.

MAIN INVESTIGATION

The fish offals were divided into ten parts, each part being weighed before and after processing. Recovery of dry matter was calculated, taking as a basis of 100 per cent recovery the fish which was dried directly. The original wet weight of fish taken for each sample was 2 kg. and each sample was spread for drying to cover an area of 14 in by 16 in. All oven-dried samples were dried for two hours at 45° C. and finished at 70° C. The processing and chemical composition of the respective parts is expressed in Table I.

There is a considerable difference in drying time between cooked and uncooked fish, but there is very little difference between sun and hot air current drying. There is also a considerable reduction in the percentage of oil in cooked and squeezed meal, but very little variation in the meals prepared from cooked fish.

To be able to make direct comparison of the above processes the chemical composition of each is expressed in Table II on a "Dry Matter" basis and also the calculations were made of the losses during processing and the total yield of proteins.

From Table II it can be seen that No. 6 process produced good-quality meal with a low oil content, while the losses were negligible. The oil content of the fish dried by the direct method (No. 8), 13 per cent, was too high to be accepted for the tropics. Process No. 1 produced good-quality meal but the losses were much higher than in No. 6. No. 5 meal had a higher oil content and the product itself was of inferior appearance due to cooking in insufficient water.

Further investigations were made into the possibilities of steaming and autoclaving instead of cooking. The material used was similar but it had fewer bones. The chemical composition is shown in Table III.

TABLE III.—CHEMICAL COMPOSITION OF FISH MEAL PREPARED BY STEAMING OR AUTOCLAVING

Process	Dry Matter %	Total Ash %	Crude Oil %	Crude Protein %	Nitrogen Free Extract %
Fish, minced, steamed ten minutes. Squeezed, dried by hot air current ..	92.83	20.36	1.86	66.56	4.05
Fish, minced, autoclaved at 5 lb. for ten minutes. Squeezed, dried by hot air current ..	90.2	24.04	2.39	63.64	0.13

Although the chemical composition is somewhat better, the material was in both cases discoloured and of an undesirable texture which made pressing difficult. As these processes require more elaborate apparatus and the resulting discoloration of the meal reduces the market value, these processes were abandoned.

Comparison of Different Materials Processed as Sample No. 6.—The fish meals were prepared according to process No. 6 from different materials and the meals in all cases were of good appearance and good keeping quality. Table IV shows the types of material used and the chemical composition obtained from them. For comparison, some of them were prepared by direct drying of minced fish.

TABLE IV.—CHEMICAL COMPOSITION OF FISH MEALS PREPARED FROM DIFFERENT MATERIALS ACCORDING TO PROCESS No. 6

Methods	Dry Matter %	Total Ash %	Crude Oil %	Crude Protein %	N.F.E. %	Losses %	Vitamin B 12, µg MBA/g
Sample 6	94.2	28.3	4.81	58.48	2.61	5.7	0.345
Sample A. Fish meal prepared from Ngege fillets from Lake George	89.13	4.7	2.75	84.28	—	20.00	—
Sample B. Fish meal prepared from a further batch of Ngege fillets from Lake George ..	90.83	2.5	0.69	84.66	2.98	—	—
Sample C. Fish meal prepared from a mixture of Mamba and Male fillets from Lake George	91.48	3.1	2.33	84.83	1.22	16.1	—
Sample D. Fish meal prepared from Heads and Tails from Lake George	90.48	34.495	5.31	47.644	3.25	—	—
Sample E. Fish meal prepared from Nile Perch	90.68	37.66	6.64	41.4	4.96	—	—
Sample F. Fish meal prepared from Heads, Tails and Guts without swim bladders from Lake George	92.5	27.765	4.89	57.00	1.84	—	—
Sample G. Fish meal prepared from small fish, mainly *Hapochromus* sp., from Lake Victoria	89.32	25.4	12.79	47.94	3.19	—	0.8
Sample 9	94.3	24.1	12.30	56.76	1.11	—	0.24
Sample B. Fish meal prepared by direct drying from Ngege fillets as used Sample B	90.2	4.03	4.6	86.0	—	—	—
Fish meal prepared by direct drying from Mamba and Male fillets as used for Sample C. ..	97.8	5.64	2.8	84.936	4.424	—	—

It is clear that the chemical composition varies with the material used, and in fish meal prepared from offals containing a considerable quantity of bones and guts the percentage of protein is considerably lower, while in meal prepared from fillets the proteins are very high. Also, wherever guts were included the "Nitrogen-free extract" was relatively high.

It was found also that the optimum quantity of water for cooking in No. 6 process was one pint for each pound of raw fish. The time of cooking was reduced from five minutes' boiling. The water and fish were heated to 85°–90° C. The meals obtained this way were exactly the same as when more water was used and when boiled for five minutes. There are considerable differences in protein content between the meals prepared from different species. Ngege (*Tilapia nilotica*), Mamba (*Protopterus æthiopicus*), Male (*Clarias lazera*) were superior to Nile Perch (*Lates albertianus*) and Hapocromus species. At the same time Hapocromus fish meal contained a very high level of vitamin B_{12}.

KEEPING-QUALITIES OF FISH MEAL

There is no good chemical or bacteriological routine method for checking the keeping-quality of fish meal. In this experiment, the smell of meals and the toxicity or otherwise to chickens were used as criteria of keeping-quality. The fish meal prepared by direct drying kept in good condition for two to three months and then began to deteriorate, when it was possible to detect a rancid smell. The fish meals prepared by No. 6 process were kept for seven months in open and closed containers without apparent changes. They were then fed to six-week-old chickens at a rate of 5 per cent of the ration. They were eaten readily by the chickens and did not produce any adverse effect.

DISCUSSION AND CONCLUSIONS

Different methods of preparing fish meal were investigated. There is very little variation in percentage of proteins in all these meals, the main differences appearing to be in the oil content of the meals and in losses of dry matter during preparation. There are no significant differences between sun-dried or hot-air-dried meals. Precautions must be taken against ants, as the meals are liable to be attacked by ants while being sun dried. The boiled and squeezed fish does not attract flies but this is not the case with raw fish, which needs protection even during hot-air drying.

As sun drying reduces considerably the cost of preparing fish meal, it should be used whenever possible. The biological values of the proteins of sun-dried meal should be superior to that of hot-air-dried meal, as it is exposed to a high temperature only during cooking while the other is exposed to the hot-air current for some hours. At the same time, the sun-drying depends on the weather, and for any fish meal plant working continuously it would be necessary to have some alternative means of drying.

All the meals have a high vitamin B_{12} content. The fish meals produced by No. 6 process are the richest in this vitamin. In addition to this, process No. 6 produces a fish meal which combines low losses during processing with good keeping qualities. These losses vary with both the type and freshness of the materials used. The amount of oil left in the meals after No. 6 processing is sufficiently low, with all types of fishes that have been investigated, to ensure good storage, even of sacked meal, for a long period. The trials of keeping-quality of meals which were carried out in this laboratory lasted only seven months. During this period none of the fish meals prepared by cooking, except process No. 5, showed any noticeable deterioration. The meals prepared by direct drying began to show noticeable deterioration after two months' storage. Our observations of the keeping-quality of meals led us to believe that under local conditions the oil content of meal should be kept below 6 per cent to ensure good storage.

For both economical and nutritional reasons care must be taken to reduce to the minimum the temperature and the time during which the material is exposed to heat. It was also noted that a high initial drying temperature caused darkening of the fish meal, but if the squeezed cooked fish was dried in the first instance for two hours at a temperature not higher than 45° C. to 50° C. and then finished at a temperature of 70° C. there was no change in colour.

Fish meal processed by No. 6 method was exposed for a short time to a temperature of 85° C. to 90° C. and was dried at a temperature not higher than 70° C. The low temperature to which the fish was exposed should not have appreciably altered the biological values of the proteins, and in this respect this method should be superior to any others investigated.

It was concluded from these investigations that process No. 6 would be the best for small-scale production under local conditions. The process adopted finally is as follows:—

> The fish is minced, using a disc with large holes, or is chopped into small pieces. The minced material is then put into boiling water (one pint of water per pound of raw fish). This causes the temperature to drop, and the mixture is then heated as quickly as possible to about 90° C. The water is drained from the fish through muslin and the meal is then squeezed to get rid of oil. The residue is then dried by the sun or in an oven. If dried in an oven it is first dried for two hours at 45° C. to 50° C., and then finished at 65° C. to 70° C. The dried meal can be milled in a hammer mill or ground between stones. In the case of fillets, grinding is not necessary.

The fish meal prepared in this fashion, after seven months of storage, was fed to chickens and produced excellent results.

The fish meal from Ngege, Male and Mamba flesh were prepared by this process and were tested by Dr. Trowell and Dr. Welbourn as supplementary food for children and mothers. Dr. Welbourn [7] refers to fish meal as likely to be the cheapest and most concentrated source of proteins. It has to be mixed with a fairly large volume of other food as it contains a slightly gritty flavour and is distasteful to some children. In spite of these disadvantages, in her opinion the meal would be a valuable supplement to the diet and much would be acceptable in varying quantities to the majority of children.

The two fish meals were tested by Dr. Trowell, one was prepared from Ngege and had been kept for seven months in open containers and the second was one week old and was made from Male and Mamba. In his communication to us [8] Dr. Trowell states that the fish meal has been tried almost exclusively in the children's ward both among sick children who have difficulty in digesting food and also among healthy children. The meal was added to existing soups and sauces to which it gives a pleasant taste. Taken this way it has proved appetizing. It is such a concentrated food that it should not be given by itself for then it will probably be too strong. It is especially suitable for growing children and for sick persons, all of whom need extra protein.

This process can be used by a small fish meal factory or by individual fishermen, given supervision, as it does not involve any considerable initial capital.

The main part of this investigation was carried out on fishes from Lake George. The catch of fish in this lake is only a small part of the total catch of fish in Uganda. The Game and Fisheries Department [9] estimate the total catch in Uganda as 23,000 tons a year, which is roughly equivalent to 3,000 tons of proteins. Taking into consideration that the

proteins of fish are of high value they should be utilized to the greatest possible extent. It would seem that fish meal is one way of eliminating wastages.

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REVIEW

AN INTRODUCTION TO BACTERIAL PHYSIOLOGY, by Evelyn L. Oginsky and Wayne W. Umbreit, published by W. H. Freeman & Co., San Francisco (1954), price $7. 25 cts.

This is a very readable textbook for the advanced student. It is divided into some six sections dealing with: the nature of bacterial physiology; cytology and cytochemistry; populations including growth, nutrition, environment and genetics; metabolism; self-reliant bacteria, 'phages and viruses; and adaptation and virulence. Each section is introduced in general terms and several chapters of detailed description and discussion follow. The book does not attempt to quote everything which has ever been written on the subject but rather to emphasize and illustrate general principles. No references are given in the text but a number are quoted at the end of each chapter usually together with brief notes to indicate the subject matter. The questions posed at the chapter ends should stimulate the thought and critical powers of the student. Both photo and electron micrograms are well chosen and all the diagrams are very clear and expressive and the mechanical comparisons often amusing. Seldom is a complex subject presented to the student in such a light and easy style. The book should also be of interest to all those workers whose subjects impinge on bacteriology.

F.M.L.S.

THE DEVELOPMENT OF NATURAL RESOURCES FOR FOOD PRODUCTION*

By G. H. Gethin Jones, E.A. Agriculture and Forestry Research Organization

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Crop ecology, or the relationship of selected crop plants to new imposed physiological environments, comprises the basis of agronomic investigations. With a given set of climatic conditions, including temperature and light, they deal mainly with the edaphic and biotic factors as these affect plant growth. Not only are conditions made more suitable for favoured species of plants, but, by selection and breeding, plants are also adapted to meet local climatic, edaphic and biotic conditions. They can be more resistant to drought or diseases, be higher yielding or more responsive to imposed treatments. The farmer uses the basic knowledge gained to favour the growth and to give higher and more economic yields of particular crop plants found suitable to the local conditions. Similarly, animal husbandry benefits from both the provision of a steady supply of more palatable and nutritious grazing and foodstuffs—with perhaps added minerals—and by the selection of farm stock that are more suited for the conversion of feed into animal products. The two approaches are inter-related. The farmer's choice of crops and methods of farming have to be modified according to social and economic conditions.

The suitability of the same soil for plant growth can be greatly altered for the better or for the worse by imposed treatments. Intensive agriculture with high yields per acre, as practised in Europe to-day, is only possible by the use of artificial fertilizers. The original nutrient-status of virgin soils has been obscured, and the value of the land under the new conditions depends more on the permanent physical properties of the soil and the ease of cultivation and conservation. Soil impoverishment usually come about with long-continued exploitation of the land, resulting in the removal of nutrients together with a deterioration of soil structure. Greater damage is usually caused by the physical loss of the surface soil by bad farming practices, including overgrazing, than by the utilization and removal of nutrients by crop plants and grazing animals. This stresses the importance of soil conservation measures; not only the mechanical treatment of slopes, but also good farm husbandry methods.

"Soil fertility" is governed by a combination of factors. Different crops and herbage are favoured by a certain balance of climatic and soil factors, as indicated by the special requirements, of tea, cocoa, lucerne, truck-crops and pastures. There can be no absolute scale of soil fertility in terms of listed specific soil properties; neither can soils be graded in terms of responses to particular treatments. There can only be relative temporary soil fertility for a particular range of crops suitable to the local climatic conditions, always bearing in mind the physical, economic and social environment.

Over limited regions, except where there are very diverse soil types, it is the soil together with the local aerial and soil climate in combination that favour the growth of particular crops. This is illustrated in that on a farm with two or three different kinds of soil the same crops, with perhaps modifications in treatments, are often rotated over the whole farm. It is also possible to modify somewhat the effects of climate. Thus it is possible to conserve soil moisture, by the provision of vegetable mulches, shade and shelter belts, and by adopting proved husbandry methods that fit in with the seasons. With a knowledge of the requirements, it is by the addition of fertilizers that there can be the greatest changes in the crop-producing properties of soils. With irrigation it is possible to bring about very great differences in the use that can be made of any piece of land.

Crop Production in East Africa

It is interesting to note how, over the centuries, without properly planned field experimentation, the general distribution of crops and pastures and the systems of farm husbandry in rural Britain evolved into a pattern that was more or less suited to the local climatic and soil condition. With the

* Substance of a paper read at a conference on "The Medical, Agricultural and Veterinary Aspects of Food Production and Utilization in East Africa", held at Kampala, Uganda, 24th to 26th March, 1954.

coming of urban populations, mechanized cultivation and the use of fertilizers, the intrinsic soil properties became less important, and economic considerations played an increasingly greater role in farming methods. The advent of planned agronomic research, giving improved plant material and better agricultural practices, resulted in much higher yields per acre.

The European Highlands

The application of farming knowledge gained in Britain helped to hasten farming developments in the European Highlands of East Africa, but even so, there were several early setbacks due to the lack of basic information on the physiological requirements of crops and stock in new environments. There was increasing realization that techniques found suitable in temperate zones had to be subjected to critical tests before they could be adopted in East Africa. With a better distribution of crops according to the suitability of soil and climate, and with better general farming methods, we now find more or less defined regions and soils associated with particular plantation and farm crops. However, yields have remained relatively low and there remain misfits with the continued cultivation of certain crops in "marginal" areas.

With a greater appreciation of the role of improved pastures and leys, there is a steady move towards more mixed farming. The speed of the change-over is limited by inadequate knowledge of suitable grasses and more especially legumes, the best techniques to use in the different districts, and also by the lack of capital. In the European Highlands of East Africa there is scope for a greater development of the land resources by increasing the acreages and yields of crop-lands and by raising the stock-carrying capacity of grasslands.

As in the case of old-established agricultural countries, the greatest advance towards higher yields per acre has been brought about by the use of artificial fertilizers, in association with other good farming practices. There is already much evidence, resulting from numerous widespread statistical field experiments, to show that most of the wheat lands in the Highlands of Kenya can be made more productive by placement applications of phosphatic fertilizer. In one set of field experiments, involving placement applications of double superphosphate at 76 lb. per acre and sodaphosphate at 175 lb. per acre, respectively, the mean responses ranged from 340 lb. per acre for the soil type in least need of this class of fertilizer to 1,340 lb. for the most responsive soil type. Good responses with phosphates were also obtained in the Southern Highlands of Tanganyika. Over large areas the use of phosphatic fertilizers has become a part of normal farming practice. In the case of some soil types where farmers know that quite uneconomic low yields would be obtained without added phosphates, the acreages of wheat planted is limited to the amount of phosphatic fertilizers available. The annual consumption now amounts to the equivalent of about 5,000 tons of phosphoric oxide.

In the case of maize, grown on more base-saturated soils, the responses were generally less, ranging from 1.8 to 3.4 bags per acre. Grass leys showed early marked responses to both phosphatic and nitrogenous fertilizers. Most crops showed negligible responses to potassic fertilizers, and also to liming.

African Lands

In the case of African lands with increasing population, the system of shifting cultivation is becoming less feasible, and, over large areas, there is already continuous mixed cropping. This has led to the cultivation of shallow soils, steeper slopes and, in general, less productive soils. At the same time there has been an increasing amount of cropping in regions with lower and less reliable rainfall. Much of the lands which have been cropped for long periods now give low yields, and, furthermore, the extension of cultivation where this is possible is limited when dependent on the use of hand implements only. Ploughing is helpful in certain cases. With the use of animal manures or rough composts, it is only on a small part of the holding that yields can be maintained or raised, whereas elsewhere there is continued soil impoverishment.

The great need of East Africa is to find means of raising the food-producing capacity of African lands to support an increasing population at higher standards of nutrition and general living, in a permanent system of sound agriculture. This involves greater acreages under cultivation and also increasing yields per acre.

Increased acreages under Cultivation

As regards increasing the total acreage under arable cropping—which provides greater amounts of food per acre than grass—this

depends partly upon extending cropping on to lands which, for one reason or another, have not yet been so utilized. The African cultivator has already spread out to occupy and to crop to varying degrees most of the better land under adequate rainfall. The possibilities of increase depend partly upon the lands available to particular tribes and the extent to which the tribal population is increasing. Thus, certain tribes which have remained largely pastoral still hold large areas that are potentially suitable for cropping, but which are used for grazing purposes.

Apart from such considerations and the setting aside of lands for European settlement, Crown forest reserves and native forest reserves, remaining lands which, with appropriate treatments, are still available for varying amounts and kinds of cropping can arbitrarily be listed under different heads.

There are regions suitable for cropping by stock-owning cultivators which have, up to the present, been preserved by unhealthy conditions to man and his stock. There are very extensive areas with tsetse fly and also where East Coast Fever is endemic, such that calf mortality is excessive. With bush-clearing and other control methods, tsetse advance is being halted, and portions of once-infested lands, with adequate rainfall and suitable soils, are being made available for crop production.

When one comes across large tracts of suitable land remaining sparsely occupied, a frequent explanation is the lack of adequate, permanent domestic water supplies. This occurs under good rainfall where the soil and the rock below are porous, such that there are no surface streams or seepage zones. The provision of better water supplies by various suitable means is already adding greatly to the amount of land that can be more closely settled. In East Africa this task and control measures against insect-borne diseases constitute essential features of many African development schemes.

Up to the present in East Africa, very little attention has been given to the draining of lands which are unsuitable for cropping owing to seasonal impeded drainage, though in many cases simple methods such as the raising of "lands" or the cutting of open drains and/or storm drains would be effective. Incidentally, such soils in East Africa usually give good responses to phosphatic fertilizers.

Under the present system of African cultivation based on the hoe, intractable soils, though with suitable relief and adequate amounts of mineral nutrients, cannot readily be cultivated. There are extensive areas of heavy *mbuga* and so-called "black cotton soils" with a narrow range of optimum moisture content, such that the period between being moist and sticky and then drying out into a compacted soil—and vice versa—is too short for the difficult kind of cultivation needed by this peculiar kind of soil. It is interesting to note that not greatly dissimilar soils, which are self-mulching on drying out such that a seed bed can easily be prepared with the hoe, are often utilized. Similarly, on the lower, gentle slopes in peneplain country, such as in the Lake Province of Tanganyika, there are large areas of less heavy, "hard-pan" or cemented soils, which are little utilized at present. The substitution of mechanical cultivation for the hoe would make available large areas of such lands for the production of foods (including rice) and fodder crops. The conveyance of the produce and its contained nutrients uphill would reverse the natural tendencies and help to restore the fertility of the sandy soils. The bottom-lands are more suitable for mechanized group farming.

Though referred to separately, it is common to have two or more of the above-listed limiting factors obtaining in the same area. Thus, one finds intractable soils and the lack of water in unhealthy regions.

Other new sources of land for cropping so as to increase food supplies in the future depend upon the draining of different kinds of swamps. Such conditions are found as naturally dammed upland bogs, occupying valley bottoms in gently undulating country with a good rainfall, such as is common in Uganda, and also where there are stretches of gently sloping swamp land along the margins of rivers and lake shores. There are also local areas with otherwise fertile soils, but which are subjected to the hazard of occasional flooding.

In East Africa, and more especially in Tanganyika Territory, there is some scope for a relatively rapid increase in food production by making the maximum use of available water supplies for irrigating suitable soils. With the storage of flood waters, the amount of lands that could be cropped throughout the year could be greatly increased. In the case of irrigation schemes, and also swamp drain-

age as mentioned above, there will be need for detailed hydraulic and soil surveys with the study of physical and chemical soil conditions, and also possibly pilot schemes in the case of major projects.

A further source of widespread regions for the future extension of periodical cropping throughout East Africa are selected portions of the present mainly pastoral regions with a lower and less reliable rainfall. Such lands, once cleared and cultivated, are less able to maintain a vegetal protective soil covering that is necessary to prevent soil deterioration. There will be need for husbandry methods that ensure soil conservation while conserving soil moisture for the seasonal growth of suitable crop plants. The future development of such regions will have to depend on the progress made in relevant basic and technological research.

Special mention has been made of sources of new lands which, with appropriate treatments including some which have yet to be fully worked out, could be used for various degrees of cropping. The problem also involves the resettlement of crowded areas which are already over-cultivated and over-grazed. There is need to adjust the population and its stock to what the land can carry, and there will be instances where it will be necessary to rest for a while lands where the damage is excessive, and also to put aside other lands, such as shallow, eroded soils or steep slopes, under grass, bush, or forest. The settling of new lands is complementary to easing the pressure elsewhere. Soil surveys and the preparation of maps showing the distribution of different kinds of soil and other natural resources can be helpful in planning land utilization.

Increased Yields per Acre

The growing of more foodstuffs in the African lands not only depends on the cultivation of greater acreages, but also on increasing yields per acre by particular techniques that are found to be the most applicable to different crops grown under the varying climatic and soil conditions. It is necessary, not only to arrest the present fall in soil productiveness, but to raise it. This task will involve an immense amount of future investigational work trying out certain treatments under different environments and also much extension work amidst a better educated peasantry.

There will have to be the growing of the kind and variety of crop plants which have been shown to do best under the local edaphic and biotic conditions, and the adoption of farming methods that have been found to be the most practicable in giving higher yields in a system of husbandry that conserves the soil fertility. The conservation and use of animal manures and rough composts available to peasant farmers brings in no soil mineral nutrients from outside sources and, at best, can only maintain the fertility of a portion of the holding, while elsewhere there will be increasing soil impoverishment. It is likely that the soil treatment that will be found to be the most effective in rapidly increasing yields per acre over very large areas of old farming lands, and also some of the new lands yet to be brought under cultivation, will be the use of concentrated fertilizers. Special reference will be made to this aspect only of increasing yield per acre.

Fertilizer trials made with maize, sorghum and finger millets, carried out on representative soils of densely populated African lands in the three territories mainly bordering on Lake Victoria, showed varying responses to phosphatic and nitrogenous fertilizers. In one set of field experiments high responses to phosphates were obtained with two classified soil types which are very extensive. Thus, based on all 15 trials arranged on these two particular kinds of soil, the mean increase in yields per acre, following the application of 1 cwt. triple superphosphate, amounted to 480 lb. for maize and 680 lb. for sorghum. The very high mean response with the latter crop was partly due to more vigorous plants—and a better stand—being less subjected to damage by pests. Other kinds of soil represented in the trials gave lower responses, and some gave relatively better responses, to nitrogenous fertilizers. There is also the object lesson drawn from the results of fertilizer trials in the European Highlands and the adoption there of the common practice of fertilizing cereals for higher and also more economic yields.

First calculations of the theoretical requirements of African lands in East Africa that would be expected to give higher responses to phosphatic fertilizers, based on the knowledge so far available, give values of the order of 50,000 tons of phosphoric oxide per annum. Further work on the role of fertilizers in African farming should give better estimates of the likely requirements of different crops

and districts. It will be necessary to have not only widespread field trials on the responses obtained with different crops grown on different representative soils, but also to find out the best method of application, and how this new development can best be fitted into different systems of peasant farming. Care will have to be taken to ensure that supplying a hitherto limiting nutrient does not result in too prolonged cultivation before the land is again rested. However, in due course, if early findings are confirmed and it becomes the policy that fertilizers be used to increase food production, there will be need for Governments to encourage and to organize this new development along sound lines. There may be need for some form of subsidization, possibly from commodity funds, especially in the case of African lands at great distances from a port or railhead. The fertilizers would have to be highly concentrated and also possibly granular in form for ease of application. Measures necessary to bring about increased production of crops and animal products to give a higher level of nutrition, and to raise the general standard of living resulting from the sale of farm products, also involve many sociological, economic and administrative problems. It is largely a human problem.

Local Resources of Fertilizers

There is no doubt that the proper use of fertilizers will, in due course, play an important role in making possible more intensive farming with higher yields and hence alleviate the problem of increasing pressure on the land. There will be need for ample amounts of cheap fertilizers that are found to be the most suitable for East African conditions. With the present state of our knowledge, the greatest demand will be for phosphatic fertilizers. In this respect it is fortunate that very extensive supplies of primary mineral phosphates occur in the Eastern Province of Uganda. Already, several thousand tons per annum of a suitable form of phosphatic fertilizer, known as soda-phosphate, are being prepared by calcining Uganda rock phosphate with sodium carbonate which also occurs in East Africa. With the advent of abundant supplies of hydro-electric power from the Owen Falls, it will be possible to prepare locally other kinds of highly concentrated phosphatic fertilizers. With the same source of power, if it is found that there is an adequate demand, it will also be possible to synthesize concentrated nitrogenous fertilizers from the atmosphere. While being aware of the many problems involved in increasing future food production, it is good to know that East Africa can be independent of importations of the two classes of fertilizers that are most needed.

THE FAT-TAILED SHEEP OF EAST AFRICA

By H. Epstein, P.O. Box 7011, Jerusalem, Israel

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Fat-tailed sheep entered Africa from western Asia by two ways: the Isthmus of Suez and the Straits of Bab el Mandeb. The northern stream, which began to replace the original thin-tailed woolless sheep of Egypt already at the beginning of the second pre-Christian millenium, did not penetrate far enough to the south to join the southern. In East Africa, to this day, it is still separated from the southern distributional area of the African fat-tailed sheep by a broad belt occupied by the thin-tailed breeds of the Shilluk, Nuer and Dinka. The southern group of fat-tailed sheep which entered Africa through Bab el Mandeb extends from Abyssinia and the Red Sea littoral to the lake district of Uganda, Kenya and Tanganyika Territory. Farther south the native flocks consist largely of the original thin-tailed type of the Southern Bantu, with the exception of the fat-tailed sheep bred by the Hottentots and by the Bantu peoples in their neighbourhood who obtained them from the Hottentots by barter or pillage.

The infiltration of fat-tailed sheep into Rhodesia and Angola is of a relatively recent date. Half a century ago the native sheep of Southern Rhodesia were for the most part long-and-thin-tailed, only the forerunners of the fat-tailed breed of East Africa had reached Mashonaland. In a letter (dated July 4th, 1934) to Dr. A. E. Romyn, then Chief Animal Husbandry Officer of Southern Rhodesia, Mr. R. le S. Fischer, of Coldstream Ranch, Southern Rhodesia, who brought the first flock of Merino sheep to that country on behalf of Cecil John Rhodes in 1891, gives the following account of the original native sheep of Southern Rhodesia: "When I first arrived in this part of the country 43 years ago most of the natives had a few sheep at their kraals. These were similar in all respects to the Afrikander sheep you find in the Union, only a good bit smaller, due I expect to bad herding, etc.". In an accompanying letter to the author (dated July 11th, 1934) Dr. Romyn writes: "The present native sheep in this Colony are similar to those further south, but small in size, and if possible more mixed in appearance. they have apparently been evolved from a mixture of Afrikander and Blackhead Persian sheep, which to start with were mixed in type and ancestry. To this stock have been added from time to time introductions of poor type Merinos from European flocks". In a subsequent letter to the author (dated October 3rd, 1934) replying to various questions, Mr. R. le S. Fischer specified his previous account: "The native sheep as I found them here 43 years ago were as follows: a good bit smaller than the Afrikander sheep, but very similar in other respects. The rams had fat tails, but the ewes just long tails. Some of the rams had fairly large horns curving down and then backwards from base of head. The colours were black and white, brown and white, yellow and white. The coat was a mixture of fine wool and hair, which they shed once a year. Some of the ewes had small horns lying flat on the head; but I don't remember any having throat ruffs. I remember some of the sheep having short hair coats without wool."

In this valuable account the fact that the native rams of Mashonaland carried fat tails, while the tails of the ewes were thin and long, is of particular interest. Evidently Mr. R. le S. Fischer witnessed a process which has occurred since ancient times in many parts of Africa where the distributional areas of the fat- and the thin-tailed sheep adjoin, the owners of thin-tailed flocks endeavouring to change this feature by using fat-tailed rams for breeding purposes wherever they could get hold of such. For the fat-tailed sheep possess two advantages over the original thin-tailed sheep of native Africa: they grow coarse wool in addition to fat deposits on their tails. Many of the native peoples of Africa, outside the rain forest area, are nomadic or semi-nomadic pastoralists, not in possession of swine. They lack a fat-producing animal; and the relative speed with which the original thin-tailed breed has been replaced by fat-tailed animals, wherever these have become known, is due mainly to this fact. Moreover, in semi-arid regions the adaptability of fat-tailed or fat-rumped sheep is superior to that of thin-tailed breeds which have no special fat reserve to carry them over the frequent periods of drought.

It is remarkable that fat-tailed sheep have never penetrated into Congoland where the climate apparently does not suit them. In fact the change from the fat- to the thin-tailed type is decidedly abrupt all along the Albertine Rift Valley (Johnston, 1907). The absence of fat-tailed sheep from Congoland may be ascribable partly to the fact that most of the settled negro peoples of the forest belt breed pigs and dogs for food, having therefore no need of the fat-producing type of sheep which is the main source of animal fat with the pastoral peoples of Africa.

In Nubia and Abyssinia fat-tailed sheep occur along with thin-tailed long-legged animals. Some of the fat-tailed sheep carry fleeces of coarse black or white wool, but the majority displays a hairy coat. Hilzheimer (1928) writes that the Abyssinian sheep is the only hairy breed furnished with a fat tail. But this statement is erroneous, as hairy fat-tailed sheep occur in numerous parts of Africa where fat-tailed and thin-tailed breeds intergrade, in addition to southern and eastern Asia. Commonly Abyssinian sheep are polled in both sexes. Vestigial ears or the complete absence of the auricula are a wide-spread feature among them. The throat and neck are furnished with a dewlap of adipose tissue. Usually the fat tail is short and dumpy, with the thinner end hanging straight down; but some specimens display large heavy tails, with the thin tassel turned upwards in the centre of the tail. With their thin bodies, long legs and drooping rumps, the Abyssinian sheep represent the typical desert type.

Abyssinian fat-tailed ram. After Hilzheimer

Another fat-tailed ram from Abyssinia. After Hilzheimer

Abyssinian fat-tailed ewe and lamb. After Heck

In Eritrea the fat-tailed type, which is found along with thin-tailed and fat-rumped breeds, is bred mainly by Mohammedan tribes. Occasionally the rams are furnished with horns, but commonly these sheep are polled, with ears of moderate length, rarely vestigial, a nearly straight profile, and a fat tail of medium length. The fleece is moderately long, fine and open, but not woolly, usually white or yellowish in colour, in some instances red and white or red throughout.

Horned fat-tailed ram from Eritrea.
Photo.: Dr. Y. S. Goor

In Somaliland fat-tailed sheep are found only in the possession of the Danakil tribes, the majority of the sheep of the peninsula being fat-rumped (Mueller, 1903). Bartema, travelling in A.D. 1503, gives the following account of the fat-tailed sheep of Zayla: "There are also sheep altogether white, and having tails of a cubit long, and hanging down like a great cluster of grapes, and have also great laps of skin hanging down from their throats, as have bulls and oxen, hanging down almost to the ground" (Burton, 1856).

In Kenya fat-tailed sheep are kept in high altitudes under cold rainy conditions, the dry areas of the lower-lying parts being stocked with fat-rumped animals. The sheep in the immediate vicinity of Nairobi are those of the Kikuyu. They are a very mixed breed, having been continually influenced by the acquisition of sheep from other tribes. In the Masai country near Nairobi a distinct type is found, very large, with a short fat tail, and a hairy coat commonly brown in colour (Lydekker, 1912).

The native sheep of Tanganyika Territory are classed into three main groups (McCall, 1930):—

1. The Masai or Karakul type.
2. The black-headed Persian type.
3. The nondescript, mixed coloured, Tanganyika type.

The Masai sheep of Kenya and Tanganyika Territory are mostly large long-legged sheep, very often uniformly dark brown, but at times brown and white. The top hair of the coat is coarse and kempy, but underneath they carry a foundation of wool. The dewlap and fatty deposits along the back of the head and neck are moderately developed; tassels on each side of the throat are frequent. The tail is relatively short and thick, showing a medium dorso-ventral rut as if the end of the tail had begun to divide bilaterally symmetrical bifurcations (McCall, 1930). Nichols (1932) describes the Masai sheep as short-tailed and fat-rumped. But there is little doubt that actually these sheep belong, not to the fat-rumped but to the fat-tailed type, although their tails are shorter than in the majority of fat-tailed breeds. A similar type, the Lumbwa sheep, is rightly described by Nicholas as "smaller, with a more rounded body, a fat tail and a coat consisting of slightly longer hair".

Masai wethers. After McCall

Black-headed fat-tailed ewes from Tanganyika Territory. After McCall

The black-headed sheep, according to McCall (1930), to all intents and purposes closely resemble the so-called black-headed Persians which have been bred in South Africa for many years.

McCall's description of the black-headed sheep of Tanganyika Territory as being of Persian type, and his classification of the native sheep of this Territory into three groups, are not supported by Hornby (1938): "The indigenous sheep of Tanganyika Territory," Hornby writes, "are fat-tailed, haired sheep, by which is meant the tail is flattened and often very fat, and the coat consists mostly of hair, at any rate it yields no wool capable of being spun or woven. McCall refers to three groups of native sheep in Tanganyika Territory. Of these the Masai group or breed is a well-defined one, but it is doubtful if a separation can be effected between his other two groups. He speaks of a 'Persian type' yet depicts fat-tailed sheep obviously different from the true Persian sheep; which is fat-rumped, and is rarely found among the native-owned flocks of this Territory. For the present we recognize as two distinct breeds: (1) the short-fat-tailed sheep of Masailand and (2) the long-fat-tailed sheep of Ugogo. But one meets with so many individual sheep that have tails different from either of these, e.g. those with a broad shield-like tail which does not come to a point like that of the Ugogo sheep, that one realizes how arbitrary the above classification is."

Sheep breeding is an ancient element in the economy and culture of the Masai, as indicated by their use of the "ram's apron", a piece of stiff leather attached to the belly of the ram to prevent breeding out of season. The invention of this device is attributed to the Masai, as it is employed by only one other people, i.e. the Wagogo, who seem to have learned its use from the Masai (Kroll, 1928). Also the Masai, alone among African tribes, occasionally dock the tails of their fat-tailed ewes in order to facilitate service; and they milk the ewes, a practice restricted, in Africa south of the Equator, to an insignificant number of native peoples, such as the Warangi, Wagogo and Hottentots, who may have acquired it from the Masai or, as in the case of the Hottentots, among whom only women and children are allowed to drink ewes' milk (Epstein, 1937), from another East African people influenced by Masai culture.

In the Northern Frontier Province of Tanganyika Territory a small light-bodied sheep, known as the Samburu, is found. It is similar in many ways to the Masai, but is very variable in type and colour, many specimens being spotted; it has also a slightly longer tail than the Masai with less fat deposited at the rump regions (Nichols, 1932). According to Lydekker (1912), the Suk and Samburu sheep represent a distinct type; small as compared with the sheep of the Masai, hairy, and with a long fat tail coming to a curved point near the ground. The predominant colour is white.

Outside the sphere of the Masai, the native sheep are usually small, stout, and variegated in colour. There are white sheep with black, brown or yellow heads, indicating the influence of the fat-rumped Somali breed; others are piebald, skewbald, spotted or blue roan; a uniform colouring of any shade is rather rare and limited to white, black or tan.

Sheep with vestigial ears from the Central Province of Tanganyika Territory. After McCall

The fat-tailed sheep of East Africa are frequently devoid of the external ear. This condition is seen in every degree of variation from a perfect ear to an ear of which only the scantiest vestige remains. Occasionally the orifice of the ear is so small that it will not permit the introduction of anything thicker than a pencil. On the Island of Socotra, off the Somali coast, this condition is even more general than among the fat-tailed sheep of the eastern coastal region of the Continent. "Lambs out of these vestigial-eared ewes," writes McCall (1930), "if sired by a normal ram frequently exihibit the peculiarity of the dam, so that the genetic factor governing the formation is relatively potent." According to Wriedt (1927), the absence of the auricula in sheep is due to a single hereditary factor. In crossing earless sheep with animals having ears of normal length, the entire first filial generation carries ears of about half the normal size. If such short-eared sheep are interbred, the following F_2-generation is composed of 25 per cent homozygous earless sheep, 25 per cent

homozygous for ears of normal length, and 50 per cent heterozygous short-eared specimens.

The fat-tailed sheep of the lake district of Central East Africa show by the marked variation in tail structure the influence of fat-rumped as well as of long-and-thin-tailed sheep. In some the tail is comparatively short, fat and carried high up on the buttocks, in others long and thick, reaching nearly the ground, and covered with an abundance of fat, extending almost to the extremity, while still others have tails with the adipose tissue confined to the upper third, the remainder being comparatively thin (McCall, 1930).

Fat-tailed ram from Uganda. After Johnston

In the western parts of Uganda and in Toro the sheep grow to a tremendous size, and have exceptionally fat tails. Usually they are polled; only occasionally the rams are furnished with horns. They sometimes develop a mane in front (Johnston, 1902). This character is probably due to interbreeding with the original maned and thin-tailed sheep of these regions.

Ram and ewe of the large fat-tailed Unyoro breed. After Johnston

In Northern Rhodesia both fat-tailed and thin-tailed sheep are bred by the natives. The prevalent colours are red-and-white, red-and-brown, black-and-white, and red. The ewes are usually polled but in rams the horns are sometimes well-developed, and sometimes mere nubbins. As in Southern Rhodesia the local breeds have been influenced by the introduction of Blackhead Persian sheep from the south. The marked variation in colour, type of hair, and the size of the horns of rams signifies their mixture in type and ancestry.

The fat-tailed sheep of South Africa are of two breeds: the Namaqua along the west coast, and the Ronderib Afrikander in the possession of European farmers. The Namaqua, in common with all other Hottentot tribes, had acquired their fat-tailed sheep, prior to their arrival in South West Africa, in the vicinity of the lake district of East Africa whence they were driven out, at the end of the fourteenth or the beginning of the fifteenth century, by a more powerful race armed with bows and battle-axes. From the fat-tailed Hottentot sheep the Cape Boers subsequently developed the Ronderib Afrikander breed.

Nama ram. After Schlettwein

Nama ewes. After Schultze

THE ORIGIN OF THE FAT-TAILED SHEEP OF EAST AFRICA

There is an important difference in the general character of the fleece between the fat-tailed sheep that entered Africa from Palestine by way of the Isthmus of Suez, and those that arrived from Arabia through Bab el Mandeb. In Egypt and the Atlas countries the fat-tailed sheep are superior in wool to those of East Africa where numerous fat-tailed sheep are woolless or grow a mixture of kemp and coarse wool.

Various factors have contributed to this difference. Since ancient times the Atlas countries are famed for their wool industry in which the Romans were interested not less than the Carthagenians had been before the destruction of their city and trade. In East Africa, on the other hand, wool has always been of minor importance in the economic life of the native pastoralists. Further, fat-tailed sheep seem to have reached Africa in far greater numbers by way of Suez than through the passage to the south of the Red Sea. Therefore, the northern stream may be less influenced by the original thin-tailed woolless sheep of Africa than are the fat-tailed sheep that entered Africa by way of southern Arabia. Again, the fat-tailed sheep arriving through the Straits of Suez came from Palestine, Syria and Mesopotamia, ancient centres of trade and civilization, where the fat-tailed type has been bred uninfluenced by hairy sheep for over three thousand years, and where the production of woollen materials is an ancient craft, as indicated by the famous Phœnician wool-dyeing industry. But the fat-tailed sheep coming through Bab el Mandeb had undergone far-reaching modifications already in the Arabian peninsula.

At the present day the sheep of Arabia consist of two main types: a short-haired fat-rumped breed, similar in type and colour to the Somali sheep and the so-called Blackhead Persians of South Africa, and the fat-tailed type, now restricted to the northern and central parts of the Peninsula, but which, before the advent of the fat-rumped breed, seems to have extended to southern Arabia as well.

Fat-tailed sheep have an old history on Arabian soil. Already Herodotus stresses the great length and weight of the fat tails of the Arabian sheep. But they were not the first sheep to enter the Peninsula. They doubtless came upon a still earlier stratum of thin-tailed woolless sheep traces of which can be detected to this day in the present fat-tailed breeds of Arabia, i.e. the sheep of Nejd and Hejaz.

Nejd ram

Hejaz ram

Several points in the conformation of the Nejd and Hejaz sheep indicate their mixed ancestry. Foremost amongst these is the hairy character of the coat which is not found in the fat-tailed breeds of the countries bordering Arabia on the north. This character may therefore be attributable to a hairy type bred in Arabia before woolled fat-tailed animals entered the Peninsula from the north. From the well-developed mane characteristic of Hejaz rams it would further appear that this hairy breed was maned in the male sex. No traces have remained of the tail character of the original sheep of Arabia, except, perhaps, in the primitive conformation of the Nejd tail, i.e. its considerable length, narrow fat cushion and but moderate twist at the root of the terminal portion, features confirming the long-and-thin-tailed character of the original Arabian sheep.

Again, the fat-tailed breeds of sheep found in Palestine, Syria, Iraq and Iran are for the most part heavily horned in the male sex, whereas the fat-tailed sheep of Arabia are polled. From this it may be deduced that the loss of horns was caused by a genetic factor introduced by the original Arabian sheep which may have resembled the thin-and-long-tailed Nubian sheep on the western side of the Red Sea, or the thin-tailed, maned and hairy sheep of India, which are of the same general type as those of Nubia.

It is therefore obvious that the fat-tailed sheep entering Africa through Bab el Mandeb were not of the same type as those entering Arabia from the north. Before they came in contact with long-and-thin-tailed sheep in East Africa, the fat-tailed sheep coming through Bab el Mandeb had alreay been considerably modified by a long-and-thin-tailed hairy breed during their sojourn in Arabia. The primitive features characteristic of many fat-tailed sheep in East Africa cannot therefore be ascribed entirely to the influence of the original hairy thin-tailed sheep of Africa. But it is well nigh impossible to decide which particular feature is to be ascribed to the influence of the latter, and which to an Arabian primitive type.

Assyrian fat-tailed sheep from the time of Tiglath Pileser III (745–727 B.C.)

The earliest records of fat-tailed sheep in Asia are found in Mesopotamia. Fat-tailed sheep depicted at the time of Tiglath Pileser III of Assyria resemble those of ancient Egypt, differing from the recent sheep of Iraq chiefly by their concave profiles and the lesser development of the fat tail. However, it is certain that fat-tailed sheep were known in Mesopotamia long before the end of the second millenium B.C., when animals of this type brought from the east appeared on the African continent. On the mosaic standard of Ur two woolled thin-and-short-tailed sheep are depicted behind a screw-horned goat in an animal procession. Farther to the left in the same row a bull is led to sacrifice followed by a ram. The latter is represented without wool and with a clearly marked fat tail, illustrating that the ancient Sumerians were already in possession of two different types of sheep, the woolly thin-tailed and the fat-tailed. As the royal standard of Ur is dated to about 2600 B.C., the fat-tailed type must be regarded as a very ancient product of domestication.

In the quest of the home of the fat-tailed sheep and their place of origin the peculiar character of the tail permits certain conclusions. For the fat deposit in the tail represents an accumulation of reserve material, similar to the humps in the fat-humped zebus, the camel and dromedary, and the steatopygy in Hottentot and Bushwomen. Such deposits are characteristic of steppe and desert conditions, noted for the acute changes in the supply of food. The fat tail points therefore to a steppe country as the place of the evolution of these sheep. The development of store reserves of energy on which the animal draws during periods of nutritional scarcity may be explained on the basis of artificial selection. This implies that fat deposits on the tail of sheep may sporadically occur among any breed, but that it was only in desert and steppe countries and among peoples lacking other fat-producing animals that this feature was considered of sufficient economic importance for specimens with adipose deposits to be specially selected for breeding purposes.

Among ordinary sheep the occurrence of both fat-rumped and fat-tailed animals has been recorded. "The Cotswold and Romney Marsh breeds," Lydekker (1912) writes, "exhibited a marked tendency to accumulate fat on the rump almost to the degree of producing a deformity," and further: "In confirmation of the view that the accumulation of fat in the caudal region is merely a result of domestication, it may be recalled that two of the ordinary British breeds display a tendency to this feature." Ewart (1913-14) is even more explicit on this point: "In some Border-Leicester and Cotswold rams", he writes, "there is a considerable amount of fat at the root of the tail or in the buttocks." Further: "In many lambs fat tends to accumulate in

the root of the tail, while in not a few breeds, when food is abundant, fat accumulates to the extent of several inches over the rump. In this tendency to store fat . . . improved breeds . . . approach the fat-tailed and fat-rumped breeds of Central Asia." Again, "in lambs of improved modern breeds, the tip of the long tail is sometimes turned upwards."

Since there exists no economic necessity in Britain to produce a fat-tailed or fat-rumped breed of sheep, such specimens are not selected for breeding purposes; on the contrary, they are culled, as the fat deposits in the tail and rump are considered as undesirable. But there can be little doubt that fat-tailed and fat-rumped breeds could be evolved from among ordinary sheep if steppe conditions and the need of a fat-producing animal should induce breeders to select individuals distinguished by prominent fat deposits on the tail or rump for breeding purposes.

We may therefore assume that fat-tailed sheep were evolved in a steppe or desert region where fat-tailed specimens proved more resistant during periods of drought than ordinary stock, and by a people lacking the fat-producing swine for cultic or other reasons. The fat tail, then, may have been acquired long after the domestication of the original parent stock, in a country distant from its original home. Such a view is held by Antonius (1922) who suggests that the fat-tailed type was evolved in the steppes of Syria and Arabia where the climatic conditions favour the development of fat reserves. In support of this theory Antonius mentions that no data have hitherto come to our knowledge pointing to the evolution of the fat-tailed variety in other than the above countries.

While this theory is possibly correct, the available evidence is insufficient to prove it. From the point of view of environment the fat tail could have been evolved also in another steppe region of western or central Asia, as were the fat rump in sheep and the fat hump in zebu cattle. On the other hand, the fact that the Syrian desert has been the habitat of Semitic peoples (who possessed neither swine nor other fat-producing animals) since prehistoric times, and that fat-tailed sheep could thence readily have extended as far as China in the east, and South West Africa in the south; further, that the fat-tailed sheep was known in ancient Mesopotamia, but not in the ancient Indus valley, would all go to support Antonius.

The parent stock of the fat-tailed sheep has to be sought among the long-and-thin-tailed domestic breeds of Asia, a branch of which had formerly entered Africa to become there the first African type of sheep. This implies that the ancestral stock of both the thin-tailed and fat-tailed sheep is identical.

Salt Range Urial. After Lydekker

It is generally accepted that the wild ancestors of these sheep are found among the urial group of western Asia. But opinions differ as to the actual sub-species that provided the parent stock; nearly every geographical urial race has been suggested by one author or another, usually on the basis of horn size or shape, or the presence or absence of the throat ruff. The number of different suggestions demonstrates the speculative character of such discussions. For the differences between the different urial races and even between several moufloniforme species of Asia are so negligible being for the most part confined to the size of the horns and the number of their turns, which, again, appear to be largely dependent on body size and environmental factors, that it is impossible to base theories on the descent of different domesticated sheep on a comparison of their horn shapes with those of the various races or species of wild sheep. There is little doubt that domesticated descendants of any of the geographical races of the urial or

other moufloniformes could have developed ammon-, sickle- and screw-shaped horns of an upright or lateral direction, or have lost the horns altogether. The different horn shapes in domestic sheep as well as the lack of horns are the result of the domestication process; they are not in every instance due to direct and unchanged inheritance from a separate wild ancestral stock. The same applies to such features as hairiness and woolliness of coat thin and fat tails, or long and short ones, body size and colour, and many other characteristics by which the various breeds of domestic sheep are distinguished from one another. These are results of selection of inheritable variations practised by shepherds for several thousand years.

ACKNOWLEDGEMENT

The photograph entitled "Black-headed, fat-tailed ewes from Tanganyika Territory, after McCall" was reproduced from the Annual Report of the Department of Veterinary Science and Animal Husbandry, Tanganyika Territory, 1929, with the permission of the present Director of that Department, to whom thanks are due.

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THE COMPOSITION OF GREEN OATS FOR FORAGE AND ENSILAGE

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The composition and nutritive value of oat grain, straw, hay, and the green crop cut at the milky stage of growth for ensilage can be found in most authoritative textbooks on livestock feeding. Similar information on young green oats grown for forage can rarely be found in the literature, presumably because it has not been common practice elsewhere to utilize the cereal in this way [1]. It is a method, nevertheless, which is favoured in certain districts of Kenya and, if only from a parochial standpoint, information on green oats requires to be extended to include its composition under grazing conditions.

The data shown in Table I refer to oats grown on the South Kinangop, on the farm of Mr. J. F. Lipscomb. The crop was sampled in late January, 1954, after initial grazing had occurred, and again in mid-March, after it had been grazed by a dairy herd each afternoon over a period of several days.

TABLE I—THE COMPOSITION OF GREEN FORAGE OATS

(*based on* 100 *per cent dry matter*)

	29*th Jan.*, 1954 *once grazed* 9–10 *in. high*	19*th Mar.*, 1954 *frequently grazed*, 3–4 in. *high*
Ash	9.12	9.96
Crude Protein ..	30.21	34.12
Ether-Extract ..	5.82	6.46
Crude Fibre ..	17.17	21.35
Carbohydrate ..	37.68	28.11
True Protein ..	24.60	27.09
Percentage digestibility of Crude Protein ..	92.40	79.90
Lime CaO ..	0.58	0.64
Phosphoric Oxide P_2O_5 ..	0.71	0.97
Starch Equivalent	68	71
Protein Equivalent	22	26

These results show clearly that green forage oats are extremely rich in crude protein and its digestibility is very high, when judged by *in vitro* determinations using the method of Wedemeyer. The crop is also rich in oil, contains respectable levels of lime and phosphoric oxide, and is not fibrous. In these early stages of growth, green forage oats are a concentrated food for livestock, supplying a starch equivalent value of about 70 and a protein equivalent value of approximately 24.

As would be anticipated, the composition of green oats alters as the crop advances towards maturity, and the results presented in Table II illustrate the nature of the changes which occur. The cereal concerned was again grown on Mr. Lipscomb's farm, when 75 lb. per acre were drilled with the legume *Serradella* in October, 1953, in a seed-bed which received 200 lb. guano per acre. It will be seen that as the crop developes, there is a progressive decline in protein, oil and minerals. Concomitantly, there is a marked increase in carbohydrate, the crop becomes more fibrous and its protein less digestible.

In its earlier stage of growth, the green crop may be used for forage, as discussed already; alternatively, it may be used for ensilage and cut on more than one occasion for this purpose. S. J. Watson, however, has shown that although cutting earlier certainly improves the feeding value of the green cereal, its yield may then be so low that it is not worth while [2]. In his view, oat ensilage is better made when the crop reaches the "fodder" stage, that is, when the grain is still soft and milky. Maximum yields of dry matter and of crude protein per acre are obtained at this stage of growth, and by virtue of a lactic acid type of fermentation which proceeds rapidly, a very attractive silage can be produced [3].

On the South Kinangop the green cereal was cut as it approached the stage of growth advocated by Watson. Its composition about the time of cutting, on 12th February, compares very favourably with the data provided by Woodman [4] for oats cut at the "milky" stage, but it is less fibrous. Crude protein values are similar, and clearly show that when the cereal is headed out, it cannot be expected to give a protein-rich silage. By the time the green crop was ready for cutting on Mr. Lipscomb's farm, its companion *Serradella* had reached the flowering stage of growth, and its

composition prior to cutting is shown in the last column of Table II. The legume is rich in protein of high digestibility, contains a high proportion of lime, a respectable amount of phosphoric oxide and it is not fibrous. It can be expected, therefore, to enhance the protein and mineral value of the mixed crop and contribute also to its yield of dry matter.

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TABLE II.—THE COMPOSITION OF OATS WITH ADVANCING MATURITY
(*based on* 100 *per cent dry matter*)

	OATS						SERRADELLA
	KENYA				ENGLAND (from Woodman's data: Ref. 4)		KENYA (Companion to Oats)
Date	12–12–53	7–1–54	29–1–54	12–2–54	—	—	29–1–54
Stage of growth	12 in. high	18–24 in. high	early flowering	in full flower	in flower	milk stage	early flowering
Ash	10.55	11.50	8.46	5.40	7.76	7.89	11.46
Crude protein	35.28	20.24	9.05	8.13	8.19	9.39	24.36
Ether extract	5.67	3.68	3.16	2.41	2.59	3.01	3.72
Crude fibre	16.87	23.25	23.31	28.05	36.63	32.25	18.66
Carbohydrate	31.63	41.96	54.81	56.01	44.83	47.46	41.80
True protein	n.d.	14.94	4.79	4.71	n.d.	n.d.	18.75
Percentage digestability of crude protein	n.d.	84.88	74.59	46.74	73.60	54.31	89.12
Lime CaO	0.61	0.48	0.42	0.40	n.d.	n.d.	1.69
Phosphoric oxide P_2O_5 ..	0.68	0.56	0.33	0.35	n.d.	n.d.	0.55

RESISTANCE TO "TAKE ALL" DISEASE IN KENYA WHEAT 131

By A. D. S. Duff, Department of Agriculture, Kenya

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In Kenya, "Take all", *Ophiobolus graminis*, is second only to the rusts in importance as a wheat pathogen, consistently causing loss of crop in the higher areas, over about 7,500 ft. These crop reductions will continue as long as wheat mono-culture is the farming practice, or alternatively until resistant or immune wheat varieties are found. Under Kenya conditions such varieties must also bear the necessary resistance to the rusts.

In the Triticinæ, resistance to *O. graminis* is known, but few wheat varieties have this property. Some Japanese wheats are stated to be resistant [2] as are also some German varieties [3]. However, a German wheat, Rimpaus Braun Weizen, which of the 20 varieties tested proved the most resistant in the seedling stage, was the most susceptible as an adult plant. This result was obtained using a pure-culture technique. In South Africa [1], Sterling was apparently resistant in tests one year, but was heavily attacked the following season. F_I plants of Chinese Wheat × Abbuzi Rye were more resistant than Sterling, but this character was not maintained in succeeding generations.

In the higher areas of Kenya, particularly Ol Kalou, wheat 131, an old variety which was largely replaced by more Stem Rust-resistant and perhaps higher-yielding wheats, has returned to popularity mainly on account of its resistance to Yellow Ear Rust, *Puccinia glumarum*. In addition, farmers state that 131 is resistant to "Take all" which severely damages the other varieties, and as *O. graminis* is prevalent in these areas, 131 is again being widely grown.

On hearing the above contention, experiments were started to determine whether or not 131 is, in fact, resistant.

Methods

All the following results were taken from material grown in boxes in the rust cages. Pure-culture methods were not used because it was felt better to test the wheat under as near natural conditions as possible. For purposes of comparison, Kenya Governor, Sabanero, D.C. × Ceres 721 and 360H were tested with 131.

These five wheats were grown in two series of boxes. In one series root and culm debris of a "Take all"-infected crop was mixed with the soil. The other set served as control. Good "infections" were obtained in the *O. graminis* boxes and no plant in the control boxes became diseased. Root rotting and the presence of runner-hyphæ, scored on an intensity scale +, ++, etc., were taken as criteria for assessment.

In this way the performance of 131 could be compared with that of other varieties grown alongside 131 under identical conditions.

Results

Six Weeks After Planting

Several plants of each of the varieties were removed from the boxes and the roots were examined microscopically for rotting and the presence of runner-hyphæ. No above-ground symptoms of "Take all" were visible. The results are summarized in Table I.

Table I

Wheat	Root Rot	Runner Hyphae	Root System	
			Control	*O. graminis*
131 ..	—	+	Profuse	Profuse
K.G. ..	+++	++++	Normal	Extra branching
360H ..	++	++	Normal	Normal
Ceres 721	++	+++	Normal	Extra branching
Sabanero	+	++	Normal	Normal

Eight Weeks

Samples of the wheats were again examined. No above-ground symptoms were apparent, though the wheats in the control boxes appeared, on the whole, slightly larger and more robust. Table II gives the results at eight weeks.

Up to this time all boxes had been treated alike with liberal watering. As *O. graminis* acts by destruction of the root system, symptoms are intensified by drought. Half of each series of boxes were now watered very sparingly, the plants being kept at just above wilting point. The other set continued to receive abundant water.

TABLE II

Wheat	Root Rot	Runner Hyphae	Root System	
			Control	*O. graminis*
131 ..	+	+	Profuse	Profuse
K.G. ...	++++	++++	Normal	Extra branching but roots shorter due to rot
360H ..	+++	++	Normal	Extra branching
Ceres 721	+++	+++	Normal	Reduced root due to rot
Sabanero	++	++	Normal	Slight increase

Ten Weeks

Droughted boxes.—For three days before these observations were made, the plants received no water. Severity of wilting was scored on the following scale:—

(1) Practically no wilting.
(2) Only youngest leaves wilted.
(3) Youngest leaves rolled. Next leaves flaccid, lower leaves open.
(4) All leaves flaccid, young leaves rolled.
(5) All leaves rolled. Severely wilted.

A comparison of the wilting of control to *O. graminis*-infected wheats gives an estimate of actual damage to the plants caused by *O. graminis*. (*See* Table III.)

TABLE III

Wheat	Root Rot	Runner Hyphae	Wilting		Above ground take all symptoms
			Control	*O. graminis*	
131 ..	+	+	2	2	Nil
K.G. ..	+++++	++++	2	4	Present
360H ..	++++	+++	3	4	Present
Ceres 721	+++++	+++	1	5	Present
Sabanero	++	++	2	3	Nil

Watered boxes.—All plants appeared healthy though the control lots were larger and, on the whole, of better colour. A summary of these results is given in Table IV.

TABLE IV

Wheat	Root Rot	Runner Hyphae	Height of Plants, cm.		
			Control Mean	*O. graminis* Mean	% reduction
131 ..	+	++	19.6	18.7	4.6
K.G. ..	++++++	++++	21.3	19.1	9.9
360H ..	++++	+++	20	15.3	23.5*
Ceres 721	+++++	++++	19.8	17.2	13.1*
Sabanero	+++	++	22.6	18.6	17.7*

*Significant at .05

Twelve Weeks

Other general observations. (Table V.)

TABLE V

Wheat	Control	*O. graminis*
131 ..	Plants robust and healthy	Plants appear perfectly healthy. Slightly earlier death of lower leaves.
K.G. ..	Plants healthy. Dark green and in head about 10 days earlier than *O. graminis* plots.	Plants thin and light coloured. More, and earlier, death of the lower leaves.
360H ..	Large sturdy plants.	Small straggly plants.
Ceres 721	Plants healthy and dark green.	Poor thin plants. Light coloured and with early death of leaves.
Sabanero	Plants robust, large and dark green.	Plants smaller but appearing fairly healthy.

These experiments were terminated at 14 weeks. At that time the plants in both the control and *O. graminis* series had lost vigour and were root bound. All varieties except K.G. were still vegetative at that time.

CONCLUSIONS

There is ample evidence to show that while 131 is not immune to *O. graminis*, it is resistant. The plants develop more extensive root systems than those of the other varieties tested, enabling the wheat better to withstand attack. At the same time, the roots of 131 do not become heavily attacked or damaged by *O. graminis*. This shows that the wheat 131 has positive resistance to "Take all".

Experiments are in hand to estimate the actual reduction of yield of 131 compared with a more susceptible variety when attacked by *O. graminis*. It is hoped that results may be published at a later date.

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UNDERGROUND STORAGE OF MAIZE IN TANGANYIKA

By G. Swaine, Department of Agriculture, Tanganyika

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Underground storage of food grains on a commercial scale is now carried out in the Argentine, Turtle [1] and Oxley [2]. The principles worked out in the Argentine are that infested grain, of less than 13 per cent moisture content, is sealed down in an underground pit which allows neither entry nor exit of water vapour, nor exit of carbon dioxide produced by the infesting insects. Under these conditions there is an accumulation of respiratory carbon dioxide in the inter-granular air which causes the death of the insects contained in the pit. Recent work in Australia and England has shown that the concentration of carbon dioxide required to exterminate the infestation is directly related to the inter-granular oxygen concentration.

Trials on the suitability of underground storage to Tanganyika conditions were carried out between October, 1951, and June, 1953. For the purpose of these trials three pits, each of approximately 120 tons capacity, were constructed at three widely separated places in the Territory (Morogoro, Dodoma and Moshi), which it was hoped would give as much a range of infestation and grain moisture content, up to a stated maximum of 13.5 per cent, as possible. Construction of the pits was carried out for the Department of Grain Storage by private contractors to a specification based on that in use in the Argentine. This specification is given below and differs from the original Argentine one in that a Metaroc- or Pudlo-treated plaster skin is substituted for a layer of asphalt waterproofing.

Specification

(1) *Excavation.*—Pit to be excavated to a depth of 7 ft. 6 in. Length, approximately 36 ft. Width, approximately 17 ft. at ground level and approximately 11 ft. at the bottom, the side walls being sloped accordingly. The end walls to be vertical and brought up to 1 ft. 6 in. in the centre above general ground level and curved to the sides.

(2) *Concrete.*—The walls and bottom of the pit to be of concrete 6 in. thick. The mixture to be 4-2-1; small aggregate should be used and the sand as clean and sharp as possible.

(3) *Reinforcement.*—To consist of B.R.C. metal or equivalent Welmesh; approximately No. 9.

(4) *Plastering*

A—Morogoro Pit

The concrete to be faced with a half-inch thickness of plaster (two sand to one of cement) and to be treated with Metarock waterproofing compound at the rate of 3 lb. waterproofing to one superficial yard of plaster rendering.

B—Dodoma and Moshi Pits

The concrete to be faced with a half-inch thickness of plaster (two sand to one of cement) and this to be treated in turn with "Pudlo".

(5) *Finishing.*—The plaster on sides and bottom to have two coats of bitumastic paint, and the second to be sprinkled with sand before it is quite dry to avoid stickiness. A final coat of white oil paint to be applied when the bitumastic coats have dried.

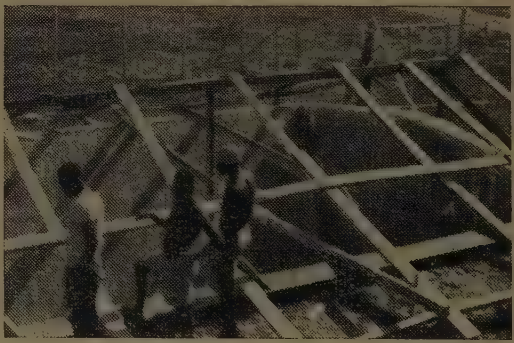

Fig. 1—Moshi pit before filling with maize. The wooden frame previously supported tarpaulins placed over the pit to keep out rain.

Techniques

Filling and Sealing

This was carried out under the supervision of the writer, bagged, infested maize from the Department of Grain Storage being used for the filling. Samples for moisture content, insect infestation and grain condition were taken from approximately every tenth bag delivered to the pits. Illustrations of an empty pit and stages in filling and sealing are given in Figs. 1, 2, 3, 4 and 5. The covering material consisted of two layers of rubberoid sheeting with a layer of chicken wire between; the rubberoid was laid down in strips over the heaped surface of the grain (Figs. 2 to 5),

care being taken to ensure adequate overlap. These strips were bituminized the one to the other and to the lip of the pit. The rubberoid over the Morogoro pit was given one coat of white paint, that over the Dodoma pit remained untreated, whilst that over the Moshi pit was covered completely with a layer of bitumen immediately after sealing down the grain. The Morogoro pit was sealed on 23rd October, 1951, and the Dodoma and Moshi pits on 24th January and 11th March, 1952, respectively.

Fig. 2—Pit completely filled with maize, the grain surface being arched and smoothed prior to sealing.

Fig. 3—Applying the first strip of rubberoid roofing material

Sampling

Sampling of the grain in the pit was carried out at intervals after sealing to determine the effectiveness of the method of storage. Small holes were cut in the rubberoid sheeting and the necessary instruments inserted for withdrawing samples of grain, inter-granular air, etc. The grain spear for removing samples of grain, Fig. 6, was obtained from Messrs. Brian Corcoran, Ltd., England, and was locally mounted on 1-in. water piping cut and threaded at 3-ft. intervals. The screwing together of the desired number of sections allowed any depth in the pit to be sampled. Grain temperatures were taken with a thermometer of the slow-moving kind mounted on a wooden spear having a steel collar threading on to 1-in. water piping.

Fig. 4—Sealing down the first strip of the second layer of rubberoid with bitumen. Note the layer of chicken wire between the first and second layers of rubberoid.

Fig. 5—Pit completely sealed. Grain being removed from bottom of pit by long sampling spear.

Samples of inter-granular air were removed by the arrangement illustrated in Fig. 7. The sampling bottle next to the ½-in. gas piping passing into the pit was separated from the vacuum pump by a water trap bottle. When the sample was known to have been collected it was then necessary to close the connexion from the sample bottle to the water trap before that to the gas piping. Trials had shown that 40 to 50 strokes of the stirrup pump sufficed to replace the air already in the sampling

bottle with air from the pit. Determinations of the carbon dioxide concentrations were made with the apparatus devised by Oxley [3], usually after transport of the bottles back to the laboratory at Morogoro and equilibration of their gas temperature to that of the laboratory by standing overnight.

Fig. 6—Grain-sampling spear being inserted through hole cut in rubberoid

Moisture content determinations were made immediately after sampling from the pit using a portable Marconi meter; allowance was made in these determinations for local variations in grain temperature.

Some early difficulties which deserve mention were experienced in obtaining reliable carbon dioxide figures. Owing to the difficulties of transporting fragile and also cumbersome apparatus in the Territory it was early decided to do carbon dioxide tests in the laboratory at Morogoro and to obtain as many gas samples as possible by the use of small, robust bottles which would not occupy too much space on the Government transport. However, it later became obvious that under working conditions such as outlined above less errors are likely to occur if large, narrow-mouthed bottles are used, even though fewer results are obtainable. In the tests reported in Table I the small bottles Nos. 1, 2 and 3 were in series with the larger bottles 7, 8 and 9 in series with the large bottles 10, 11 and 12. Sampling was from the same depth in both series.

Results

Morogoro Pit

Samples were in general taken from three places along the mid-length of the pit, at the surface and at depths of 4 ft. and 11 ft. Gas sampling only became possible 17 days after sealing owing to the late arrival of the carbon dioxide apparatus from England. Table I, which gives the average results on any one date, shows that all the *Calandra oryzæ* in the grain were killed by 31 days after sealing and that a reasonably high carbon dioxide concentration was maintained throughout storage.

Fig. 7—Sample of intergranular air being removed for later carbon dioxide determination.

The pit was opened on 14th April, 1953, 379 days after sealing. The grain was in excellent condition, although a faint musty smell could be detected in samples taken from the sides and bottom where some slight caking had taken place. This musty smell disappeared completely after the affected outer layers of maize had been bagged for a week or two. Trade representatives, present at the opening of the pit, expressed themselves well satisfied with the condition of the grain.

Dodoma Pit

The post-sealing tests on the grain were carried out in a manner similar to those for the Morogoro pit. From Table II it will be observed that live *Calandra* were present on 27th June, 1952, five months after the pit had been sealed, and that the carbon dioxide concentrations throughout storage were on the low side. The low carbon dioxide figures recorded up to the 23rd day after sealing may have been partly due to the fact that gas samples were taken in small bottles and that determination of the carbon dioxide concen-

tration was unavoidably delayed. The four last carbon dioxide figures, from 85 days after sealing onwards, were, however, obtained from samples taken in large bottles; together with the fact that live *Calandra* were present 155 days after sealing they indicate a real loss of carbon dioxide from the pit. As no faults were found at any time with the rubberoid roofing material it would appear that the facing of the Dodoma pit was not sufficiently gas tight.

When the pit was opened on 15th April, 1953, 446 days after sealing, the grain was generally found in good condition and with no live insect infestation. Local grain damage had occurred at one end of the pit where water had evidently seeped through a fault in the concrete wall resulting in the loss of some two tons of maize. It is of interest that no signs of a crack in the concrete could be detected nor in the bitumen-treated plaster skin at the point where the damage occurred, although it has since been learned that a crack in the concrete had developed at this point during construction, the damaged area being removed and completely rebuilt.

Moshi Pit

In order to eliminate any possible errors due to delays in receipt of samples all carbon dioxide testing was done on the site at Moshi. Compared with the Dodoma pit, for which carbon dioxide figures are also available from the time of sealing, it is noted (Tables II and III) that there was a much more rapid and greater accumulation of carbon dioxide and a more rapid kill of the weevil infestation in the Moshi pit. By 18th June, 1952, 99 days after sealing, the carbon dioxide concentration had fallen from the peak figure of 10.25 per cent to 3.54 per cent. It is noteworthy that in both the Moshi and Dodoma pits the water-vapour proofing treatments to the pit walls were identical and that they differed from that of the Morogoro pit where a high concentration of gas was maintained.

During the early sampling of the Moshi pit it was observed (Table IV) that differences in carbon dioxide concentration were obtained, not only with the time elapsed after sealing, but also with the depth at which the samples were taken. It is not certain whether the lower figures recorded for the surface layers were due to escape of carbon dioxide through the rubberoid cover or to the gas accumulation in the lower regions owing to its density. The Storage Officer, Moshi, reported a slight leak in the cover at the time the pit was opened and which was responsible for the local entry of water. This leak was not detected in the early stages of sampling and probably developed at a later date.

The pit was opened on 18th June, 1953, 466 days after sealing. The grain was in good condition and showed no signs of live insects. Some caking and moulding of the maize had occurred locally along two walls of the pit. No information was available as to whether this local deterioration was due to water condensation at the walls or entry of water vapour from outside.

Comparative Costs of Underground Pit Storage and Godown Storage

The total costs of construction, sealing and surrounding with a barbed wire fence of the Morogoro, Dodoma and Moshi pits have been given by the Director of Grain Storage as East African Sh. 9,411, Sh. 13,391 and Sh. 14,924 respectively. (The Morogoro figure is considerably lower than the other two as labour and transport costs in respect of the sealing were not included.) The storage cost per ton of grain was: Morogoro, Sh. 78/50; Dodoma, Sh. 111/50; and Moshi, Sh. 124. By comparison with these figures it is estimated that the cost of constructing godown storage for bagged grain is between Sh. 180 and Sh. 200 per ton of grain stored. The saving in capital expenditure by storing grain for long periods in underground pits is obvious; in addition, recurrent costs for new bags, which are inevitable in godown storage, do not have to be met.

Discussion

In only one of the three pits, the Morogoro pit, was the carbon dioxide concentration maintained at a reasonably high level throughout the period of the trials. The loss of carbon dioxide from the Dodoma pit would appear to have been due to its diffusion through the concrete walls of the pit and their plaster surfaces, in that no fault was found with the rubberoid sheeting, or to its passing out at a site where water penetration subsequently revealed a constructional defect in one of the walls. The fall in carbon dioxide concentration in the Moshi pit is difficult to understand. No constructional defects revealed themselves when the pit was emptied and no defects were found in the rubberoid cover in the early stages

of sampling when the carbon dioxide concentration increased to a maximum and then rapidly declined.

Despite the anomalies in the Dodoma and Moshi pits in respect of carbon dioxide concentration the original weevil infestations in all three pits were completely exterminated, although the secondary pest, *Tribolium castaneum,* still remained alive in small numbers when the Moshi pit was opened. With the exception of the two tons of water-damaged grain in the Dodoma pit the maize at the end of the storage periods, ranging from 379 to 466 days, was in a very satisfactory condition and considerably better than would have been the case had it been stored in bags in a conventional godown. It is obvious, however, that every care should be taken over the actual construction and that close examination for defects should precede the use of a pit before prolonged storage is undertaken.

The efficiency of the water-vapour proofing used in the Dodoma and Moshi pits is open to some doubts; either an asphalt water-proofing originally specified by the Argentine workers or some other well-tested material should be used in future pits. Local failure of the rubberoid covering in the case of one of the pits indicates that a search for alternative materials would also be worth while.

The relative cheapness of construction of underground storage compared with godown storage is a considerable factor in its favour. The cost per ton figures quoted in this report are derived from the actual cost of a 120-ton underground pit and from the cost of a conventional godown storing approximately 3,000 tons. With larger underground pits, in which the ratio of surface area to volume decreases, the cost would be expected to be proportionately lower.

Summary

1. An account is given of trials on the long-term storage of maize in underground pits in Tanganyika. The storage periods in the three 120-ton pits constructed were 379, 446 and 466 days respectively.

2. The details of construction are given.

3. The method of sealing the pits is described and illustrated and the techniques and results of sampling given.

4. Complete elimination of the weevil population by respiratory carbon dioxide occurred in all three pits. Owing to escape of carbon dioxide, due to constructional or sealing faults, small numbers of the flour beetle, *Tribolium castaneum,* survived in one of the pits.

5. Apart from the loss of two tons of grain, due to a local constructional fault in one of the pits which allowed the entry of water, the maize removed at the end of the trials from all three pits was in a very satisfactory condition and considerably better than would have been the case had it been stored in bags in a conventional godown. The practical utility of underground storage in Tanganyika can now be considered as established.

6. Further work is required to discover more reliable materials for water-vapour proofing of the pits and which are also impermeable to carbon dioxide. The possibility of loss of carbon dioxide through the rubberoid sheeting used requires investigation and search for alternative materials should also be made.

7. Constructional costs for underground pits are less than those for godowns holding the same quantity of grain.

Acknowledgments

Thanks are due to Mr. G. H. Rulf, O.B.E., Director of Grain Storage, for the arrangements in connexion with the construction and sealing of the pits and for his continued interest during the course of the trials. Information on the relative costs of storage in pits and in godowns was kindly supplied by his department.

Mrs. C. A. Wyatt, Entomologist's Assistant, has given considerable help in the sampling and subsequent laboratory work. Of the African members of the staff who have assisted in the trials special mention must be made of Mr. Abdallah Mohamed Tengeni who has supervised the taking of samples and records on a number of occasions.

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TABLE I.—SAMPLING DATA FOR THE MOROGORO PIT

Sampling date	No. of Calandra per Pound of Grain			Per cent Damaged Grains	Grain Temperature at depth below 3 ft. (Centigrade)	Per cent CO_2 in inter-granular air	Grain Moisture Content
	Alive	Dead	Emergence up to 30 days				
Before Sealing ..	4.0	—	—	1.7	32.4	—	11.35
	5.8*	2.0*	2.0*	5.9	—	—	—
Days after sealing—							
6	0.0	5.5	0.4	1.5	33.9	—	—
16	0.2	2.8	0.0	2.8	34.2	8.34	11.5
30	0.0	3.2	0.0	1.8	35.4	6.87	11.8
58	0.0	3.9	0.0	2.0	33.7	5.91	—
77	0.0	5.86	0.0	3.3	32.6	7.14	11.9
164	—	—	—	—	—	8.50	—
241	0.0	1.11	0.0	7.0	—	10.17	—
379	0.0	3.06	0.0	—	—	—	—

Pit sealed 23–10–51; opened 4–11–52. Storage period 379 days.

*Figures obtained on a single sample only.

TABLE II.—SAMPLING DATA FOR THE DODOMA PIT

Sampling date	No. of Calandra per Pound of Grain			Per cent Damaged Grains	Grain Temperature at depth below 3 ft. (Centigrade)	Per cent CO_2 in inter-granular air	Grain Moisture Content
	Alive	Dead	Emergence up to 30 days				
Before Sealing ..	3.4	3.8	—	12.6	—	—	—
Days after Sealing—							
2	0.5	6.9	4.8	14.3	35.4	4.35	10.80
4	0.0	4.8	3.2	17.7	34.5	4.04	10.73
6	0.0	2.7	2.7	15.7	33.9	5.68	11.17
8	0.0	1.9	0.5	17.7	35.4	2.50	10.60
11	0.0	0.0	0.0	17.3	33.0	2.60	10.63
13	6.4	0.0	0.5	14.0	32.9	2.07	11.10
15	0.0	4.8	2.1	12.3	33.0	1.53	11.78
18	2.7	4.8	0.5	13.0	—	1.07	12.05
21	0.0	1.6	0.8	13.0	31.5	1.59	11.55
23	0.0	1.6	0.0	8.7	29.9	1.15	11.53
85	—	—	—	11.0	—	2.06	—
155	0.04	1.5	2.4	14.3	—	1.54	—
315	0.0	8.0	0.0	—	—	1.21	11.80
446	0.0	0.71	0.0	8.3	—	2.51	12.40

Pit sealed 24–1–52; opened 14–4–53. Storage period 446 days.

TABLE III.—SAMPLING DATA FOR THE MOSHI PIT

Sampling date	No. of *Calandra oryzae* per Pound of Grain			No. of *Tribolium castaneum* per Pound of Grain			Per cent Damaged Grains	Grain Temperature at depth below 3 feet (Centigrade)	Per cent CO_2 in intergranular air	Grain moisture Content
	Alive	Dead	Emergence up to 30 days	Alive	Dead	Emergence up to 30 days				
Before Sealing ..	3·1	1·0	18·0	4·6	4·0	12·3	7·8	24·0	3·03	12·07
Days after sealing:										
0	1·4	0·3	1·2	1·0	1·7	2·6	11·7	31·4	7·35	11·40
1	0·0	1·7	2·6	0·3	0·0	0·5	10·3	33·6	9·52	11·38
2	0·0	4·1	2·4	0·7	1·0	0·3	9·7	31·9	10·25*	11·60
3	0·0	2·1	—	0·0	2·1	—	7·5	33·3	9·12	11·20
4	0·0	2·1	0·3	0·0	1·6	0·0	9·5	31·8	8·79	11·25
5	0·0	2·6	0·8	0·0	3·1	0·3	8·5	33·5	8·71	10·95
6	0·0	7·2	0·3	0·0	2·6	0·0	9·3	33·0	7·99	11·00
99	0·6	1·3	0·8	0·3	2·7	0·8	9·4	29·4	3·54	11·53
283	0·0	3·0	0·0	0·3	3·0	0·5	—	—	4·60	11·90
466	0·0	3·4	0·0	0·2	3·7	—	6·9	—	—	12·00

Pit sealed 11–3–52; opened 18–6–53. Storage period 466 days.
*Based on samples taken from centre of the pit only.

TABLE IV.—VARIATION IN CARBON DIOXIDE CONCENTRATIONS WITH TIME AND WITH SAMPLE DEPTH (MOSHI PIT)

Sampling date	Centre				Centre			
	Sampling Depth				Sampling Depth			
	Surface	1 ft.	4 ft.	11 ft.	Surface	1 ft.	4 ft.	11 ft.
Days before sampling—								
1	—	0·69	3·30	5·08	—	—	—	—
0	—	5·67	7·61	8·76	—	—	—	—
Days after sealing—								
1	9·13	8·99	10·84	11·13	6·20	7·28	9·86	12·69
2	1·79	7·90	10·75	12·10	—	—	—	—
3	9·20	9·23	11·01	11·03	5·83	8·25	9·79	10·75
4	7·85	9·33	—	10·60	6·64	7·60	9·39	10·12
5	8·87	9·02	9·54	9·80	7·00	7·87	8·89	8·72
6	8·58	8·65	9·10	8·76	6·00	6·44	8·02	8·35
Average ..	—	7·46	8·88	9·66	6·33	7·49	9·19	10·13

NOTES ON EAST AFRICAN APHIDS

VI—CEREAL AND GRASS ROOT-FEEDING SPECIES

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About 15 cereal and grass feeding aphids are known to occur in East Africa. Five of them live only at or below soil level and these are described here, together with a few other species that may have been overlooked in the past or be introduced in the future. There is little information about the economic importance of grass and cereal root aphids in the Old World, but in America several species are recognized as pests.

The root aphids may be divided into two groups. The sub-family *Eriosomatinæ* contains white, very pale green, pale yellow or pink aphids, with short antennæ, the last segment of which has only a short processus terminalis (Figs. A–N), whose adult apteræ and immature stages of all forms have eyes of only three facets, whose siphunculi are small or absent and the winged forms of which have the media of the forewing unbranched. The second group comes in the sub-family *Aphidinæ* and resembles the ordinary "greenfly" in having longer antennæ with a slender processus terminalis (Figs. P-Z), siphunculi elongate, all stages of all forms with large compound eyes and the alatæ have the media of the forewing once or twice forked. These aphids may be of various colours but are not white, very pale green or yellow or completely pink like the *Eriosomatinæ. Anœcia*, a genus of the sub-family *Thelaxinæ*, contains wheat, barley and grass root-feeding aphids with black adult apteræ and white larvæ. The antennæ and eyes are similar to those of the *Eriosomatinæ*, but the genus may be recognized by the presence of flat cone-like siphunculi and conspicuous lateral abdominal tubercles which are absent in grass root-feeding *Eriosomatinæ*, first tarsal segments with seven hairs and with 12 to 20 hairs on the second antennal segment. The media of the forewing of the alatæ is once forked. *Anœcia* is not known from East Africa but is recorded from Egypt, Europe, Asia and North America.

Eriosomatinæ

Aploneura lentisci (Pass.) (synonym *Rhizobius graminis* Buckton) is recorded from the roots of wheat, barley and many grasses. It is a spindle-shaped aphid (Fig. A) without siphunculi and with wax plates (Fig. E) of many facets. The alatæ may be recognized by their antennæ, segments III to VI of which usually bear only a single rhinarium (Fig. C) although rarely III may have two or three (Fig. D). First tarsal chætotaxy 3:2:2 in the biological forms found in East Africa. Common in the Kenya Highlands.

Baizongia pistaciæ (L.) is not recorded from East Africa but occurs in Europe and the Middle East. It resembles *Aploneura* but is more globular, and each abdominal segment of the apteræ bears a pair of long (about 150 micro-millimetres) hairs which are absent from *Aploneura*. It differs from *Tetraneura* in the absence of siphunculi. The rhinaria on the antennæ of the alatæ are more numerous than in *Aploneura*.

Geoica lucifuga (Zehntner) from sugar cane and grass roots is a rounded aphid (Fig. F) without siphunculi or wax plates. It is fairly common on grass roots in the Kenya Highlands. This aphid resembles *Trifidaphis phaseoli*, a dicotyledon root-feeding aphid described in Part IV of this series, but differs in that the wing veins of *Trifidaphis* are dark, whereas those of *Geoica* are only faintly indicated. The apteræ may be separated in that *Trifidaphis* has a long second antennal segment bearing 20 or more hairs, has hairs scattered all over the anal plate and first tarsal segments with four or five hairs, while *Geoica* has a normal second antennal segment with only six to eight hairs; the long hairs on the anal plate are arranged in two straight rows and the first tarsal segments have only three hairs. The abdomen of *Geoica* bears numerous hairs with flattened apices while the abdominal hairs of *Trifidaphis* taper to a point.

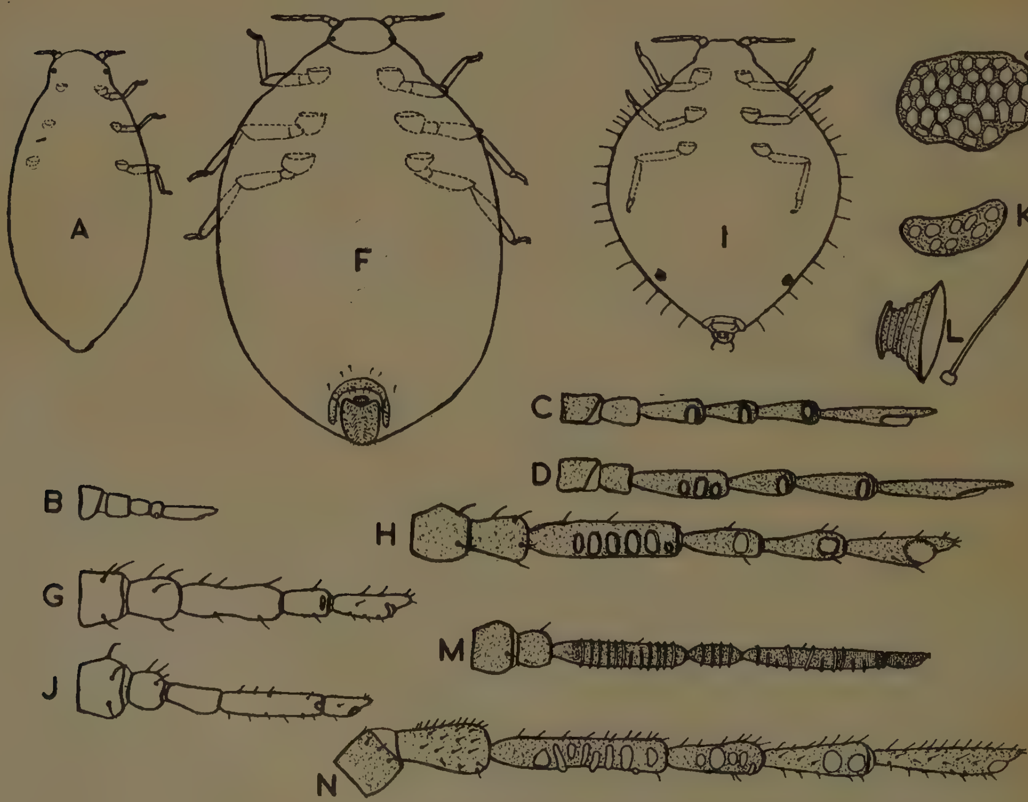
Tetraneura hirsuta (Baker), occurring on barley, rice, sugar cane and many grass roots is a globular aphid (Fig. I) with siphunculi which resemble small truncated cones (Fig. L) and with small wax plates of one to eight facets (Fig. K). *Tetraneura* differs from nearly all other aphid genera in having apteræ with tarsi of only one segment. The alatæ have two segmented tarsi with a first tarsal

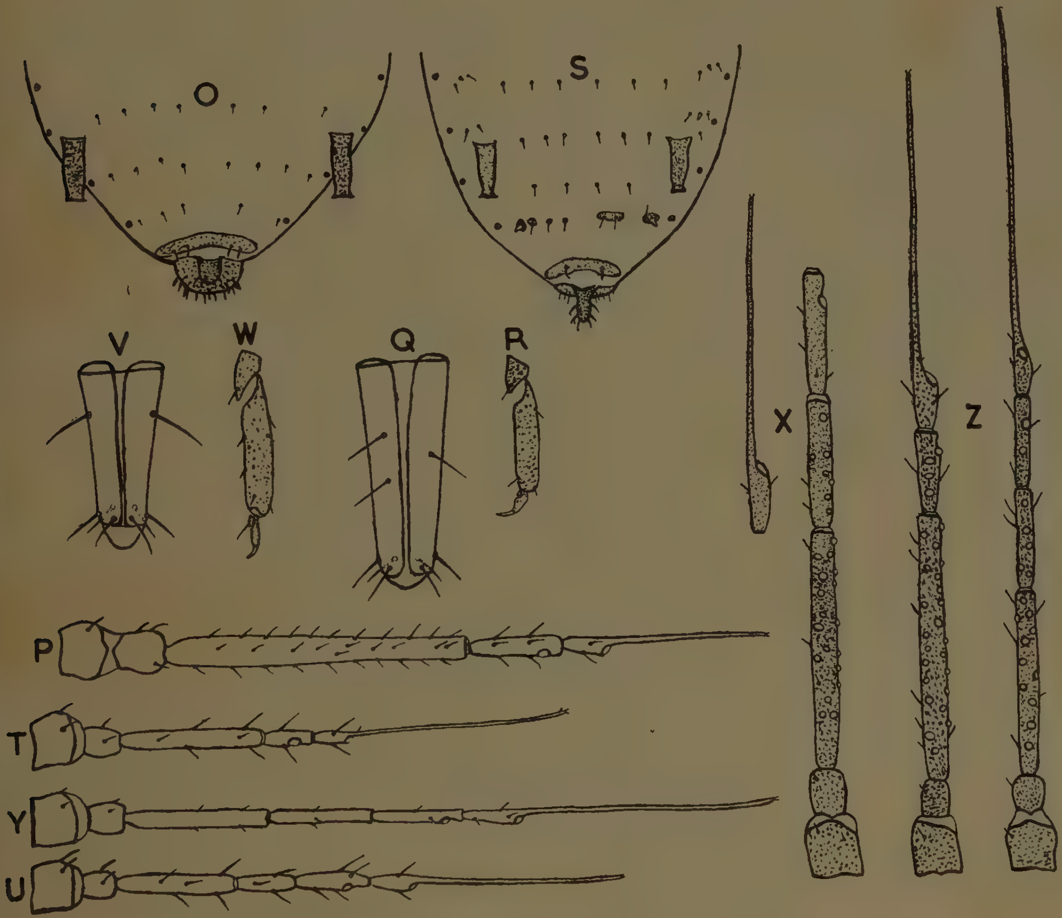
chætotaxy of 3:2:2 and the apteræ have a similar chætotaxy at the base of the tarsi indicating that the one segmented condition is the result of fusion of the two segments present in other forms. The apteræ may be recognized by the presence of very long (160 to 200 micromillimetres) lateral hairs on the abdomen and thorax. The annular rhinaria on the antennæ of the alatæ (Fig. M) will separate *hirsuta* from the winged forms of other East African grass root aphids. *T. hirsuta* is common in Kenya, Tanganyika and Uganda.

Forda is a genus of roundish or oval aphids, without siphunculi or wax plates, which feed on wheat, barley, oats, sorghum and many grasses but is not recorded from East Africa, although having a wide distribution elsewhere. *Forda* resembles *Geoica* and *Trifidaphis* but the primary rhinaria are not ciliated as they are in *Geoica* and the second antennal segment is not elongate as in *Trifidaphis*. *Forda* species have six or seven hairs on the first tarsal segment and 12 to 30 hairs on the second antennal segments.

Aphidinæ

Yezabura rhodesiensis (Hall). The only known East African material of this species was bright green in life (collected at Kawanda, near Kampala, Uganda). The original description records the abdomen as "pale brown, brownish green or plum coloured, dusky at the tip". Otherwise the Uganda material agrees very well with the description of *rhodesiensis* except for the absence of secondary rhinaria on the antennæ. It is thought that the Rhodesian material was of alatiform apteræ and that the antenna figured here (Fig. P) is of a true aptera. The alatiformity of the Rhodesian specimens may also explain the difference in colour. The apteræ resemble *Rhopalosiphum insertum* but differ in the absence of lateral abdominal tubercles, in having a very short cauda (Fig. O), in the absence of the *Rhopalosiphum* hexagonal cuticular pattern on the dorsal surface of the abdomen, by the presence of four hairs on the eighth tergite and in that the third antennal segment bears 30 or more hairs. Winged forms





LEGEND

A–E *Aploneura lentisci*, A, aptera; B, antenna of aptera; C and D, antennæ of alatæ; E, wax plate of alata. F–H, *Geoica lucifuga*, F, aptera; G., antenna of aptera; H, antenna of alata. I–M, *Tetraneura hirsuta*, I, aptera: J, antenna of aptera: K, wax plate of aptera; L, siphunculus and lateral hair of aptera; M, antenna of alata. N, *Trifidaphis phaseoli*, antenna of alata. O–R, *Yezabura rhodesiensis*, O, hind part of abdomen of aptera; P, antenna of aptera; Q, ultimate rostral segment of aptera; R, hind tarsus of aptera. S–X, *Rhopalosiphum insertum*, S as O; T and U, antennæ of apteræ, 5- and 6-segmented conditions; V and W as Q and R; X, antenna of alata. Y, *Rhopalosiphum padi*, antenna of aptera. Z, *Rhopalosiphum splendens*, antennæ of alatæ, 5 and 6 segmented conditions.

have not been seen but the description from Rhodesia states that the hind wing is greatly reduced and has only one oblique vein (as in *Hysteroneura*, recently found in West Africa but otherwise known only from America) and that the third antennal segment bears only 11 to 15 rhinaria. The ultimate rostral segment (Fig. Q) is much longer than the hind tarsus (Fig. R), in *insertum* they are about equal in length (Figs. V and W).

Rhopalosiphum splendens (Theobald) is a green aphid with a red patch at the base of and between the siphunculi. It is known from North America, Asia and Africa, and is recorded from wheat, barley, rice and several grasses. In East Africa it occurs both in the Kenya Highlands and in the Southern Province of Tanganyika. It differs from all the other *Rhopalosiphum* species known to the author in having four to six hairs on the eighth

tergite, all other species having only two. The hairs on the antennæ and legs of the wingless form are much longer than those of the alatæ (Fig. Z). The alatæ commonly have the third and fourth antennal segments fused to make the antennæ only five segmented, but specimens with six segmented antennæ, often only on one side, occur occasionally, Fig. Z shows both forms. The hind wings of *Rhopalosiphum* have the usual aphid venation of two oblique veins. When the antennæ of the alata are five-segmented the third segment bears 12 to 35 rhinaria, usually about 20, and the fourth segment bears none to four, usually two or three: on six-segmented antennæ the rhinaria are distributed, the third with 11 to 22 (average 16); the fourth with two to 12 (average $5\frac{1}{2}$); the fifth with none to four (average $2\frac{1}{2}$). Rarely, the third, fourth and fifth antennal segments may be fused to give specimens with only four segmented antennæ; the long third segment then bears 25 to 35 rhinaria.

Rhopalosiphum insertum (Walker) (synonym *Aphis cratægella* Theobald) is not recorded from East Africa but may be otherwise widely distributed, there has been much confusion in the identification of members of this genus. It is a green aphid feeding at or below soil level at the leaf bases. The apteræ of *insertum* may be separated from those of *Rhopalosiphum padi,* a leaf-feeding species that occurs in East Africa, and with which *insertum* has often been confused, by the possession of antennal hairs that are longer than the basal diameter of the third antennal segment. In *padi* (Fig. Y) the hairs are small and inconspicuous. The apteræ of *insertum* usually have the antennæ five-segmented (Fig. T), in which case the third segment bears nine to 12 hairs, the rare specimens with six segmented antennæ (Fig. U) have only five to nine hairs on the third segment. The antennæ of the alatæ may be either five- or six-segmented, the former being the most likely to occur in Kenya. When five-segmented the rhinaria are distributed as follows, III, 12 to 19 IV none to two. The six-segmented forms (Fig. X) have III, 13 to 27; IV, four to 14 and V, none to four. The six-segmented antenna is figured here as that is the form most likely to be confused with *padi.* The North American *prunifoliæ* Fitch is probably only a sub-species of *insertum.*

RELEASE OF NEW CEREAL VARIETIES—V

By H. C. Thorpe, Department of Agriculture, Kenya

(*Received for publication on 5th July,* 1954)

The following cereals have been released from Departmental control. In conformity with accepted procedure the new varieties have been tested in trial plots on the Plant Breeding Station, Njoro (7,100 ft.), and subsequently on a field scale with farmers in various parts of the territory. They have been released through normal commercial channels: and suitable notices have been published in the local Press. Fuller details of the procedure were given in an earlier article (1).

1953–54 Releases

D.C. × *Ceres R.*64

This is a single plant, rust resisfant, selection made at Njoro in 1939 in the hard red Canadian spring wheat D.C. × Ceres.

R.64 closely resembles the parent variety, being white-chaffed and red-grained and is of mid-season maturity with rather weakish straw and grain of good baking quality. It has been found resistant in seedling tests to the 12 physiologic forms of black stem rust so far identified in Kenya, but it was slightly attacked in the field in 1953 by an unknown and, possibly, new form.

R.64 is suited to all areas in which D.C. × Ceres is successful, that is from 7,000–8,000 ft., with a growing season of some 5½ to 6 months' duration.

Like the parent variety, R.64 requires good soil and high fertility for best results.

Carleton C.I. 12064

This durum, or macaroni, wheat was introduced from the United States of America, and released after test and multiplication.

Carleton is a late variety of tall stiff straw. It produces long, amber-coloured grain of good quality. It has been shown in seedling tests to be susceptible to K1 and K7 physiologic forms of black stem rust, and to be resistant to the remainder (K10 and K12 are still the subject of test).

Carleton has done reasonably well in the Eldoret and Moiben Valley areas, and proved resistant to sprouting in the wet harvest of 1951. It is suitable for areas in Kenya from 6,000–7,000 ft., having a growing season of some six months. It is not recommended for cultivation above 7,000 ft. on account of susceptibility to yellow rust above this altitude.

Carleton is of moderate yielding powers only. Nevertheless, it was felt that it might have limited usefulness as a macaroni wheat in the areas recommended.

It produces grain suitable for the Indian atta trade and may thus to some extent replace the old variety Golden Ball which has now virtually gone out of cultivation.

For this reason it was decided to proceed with its release. Since this time, however, it has been increasingly attacked by stem rust, forms K9 and K12, and its future appears doubtful.

1954–55 Releases

Wheat No. 351.*AS.I.B.*2

This wheat is from the cross 117.A × Regent 975.6, made at Njoro in 1941.

It is a beardless, white-chaffed, red-grained variety of mid-season maturity, fair straw strength, and moderate baking quality. It requires 5–5¼ months to maturity at Njoro. It has been found resistant in seedling tests to all 12 physiologic forms of black stem rust, but it was slightly attacked in the field in 1953 by forms K9 and K12. It shows resistance to yellow ear rust up to 8,500 ft. in Kenya, and is suitable for areas in Kenya from 7,000–8,500 ft.

351 is of moderate yielding powers only but it has done quite well with farmers in the Eldoret, Moiben Valley, and Kipkabus areas. In view of this, although it is not fully rust resistant, it has been decided to proceed with its release.

As 351 does not tiller readily, a seeding rate of some 10–20 lb. per acre over the usual rate is recommended.

Abed Kenia Barley

Abed Kenia is a short, stiff-strawed, 2-row barley bred in Denmark, and released in Kenya after test and multiplication.

It has yielded well on a field scale over the past few years in a number of areas in Kenya; particularly Njoro, Molo, Londiani, Kinangop and Endebess. Kenia has proved less successful in the lower areas, where over the past two seasons severe drought conditions have prevailed. The variety has shown good standing ability in Kenya as in Europe.

Abed Kenia is suitable for all areas in Kenya from 6,500–8,500 ft. (or 5,000–6,500 ft. in the Northern Province of Tanganyika) having a growing season of some 5–6 months.

Herta Barley

Herta is a short, stiff-strawed, 2-row barley bred in Sweden. It is of the same general type as Kenia and is especially notable in Europe for aggressive growth, high yield, and very strong straw. These characteristics have been maintained in this country. With its aggressive growth, however, goes a certain coarseness of grain which renders it unsuitable for malting.

Herta has been on trial in Kenya in a number of areas this past season but suffered from drought, particularly at the lower altitudes. It yielded well, however, at Kipipiri, and in the West Kilimanjaro area of the Northern Province of Tanganyika.

Herta is roughly of the same maturity as Kenia but, owing to its drought susceptibility, it is recommended for the higher and moister areas over 7,000 ft. (or 5,500–6,000 ft. in the Northern Province of Tanganyika).

Regarding quality, the Scandinavian barleys are not in general considered the best for malting purposes, although some varieties can produce malting samples when conditions are suitable. Herta, particularly, is not usually acceptable to maltsters.

Farmers have therefore, been advised to regard both these barleys as high yielding feed types rather than as malting varieties.

NOTE

Black stem rust=*Puccinia graminis tritici* (Eriks. and Henn.).

Yellow ear rust=*P. glumarum* (Eriks. and Henn.).

REFERENCE

Thorpe, H. C. (1949), "A note on the Release of some New Cereal Varieties", *E.A. Agric. J.*, XIV, pp. 210–211.

INTER-AFRICAN BUREAU FOR EPIZOOTIC DISEASES

The third annual session of this C.C.T.A. organization took place at Muguga near Nairobi, Kenya from July 28th–30th, 1954, under the Chairmanship of M. Larrat, Inspecteur-Général, Veterinary Services in Overseas France.

The representatives of the U.K. were R. J. Simmons, C.M.G., C.B.E., of the Colonial Office, R. S. Marshall, C.B.E., Inspector-General of Animal Health, Nigeria and Mr. H. R. Binns, O.B.E., Director, East African Veterinary Research Organization. Delegates were present representing other C.C.T.A. territories, viz. Belgium, Federation of Rhodesias and Nyasaland, France, Portugal, and the Union of South Africa. All the delegates were veterinarians.

The work of the Bureau in the preceding 12 months was discussed and further recommendations were made for strengthening the information, liaison and administrative functions of the organization which concerns itself with no less than 25 of the common diseases of domestic animals in Africa.

The *Bulletin of Epizootic Diseases of Africa* is compiled and edited by the Bureau and published in both French and English. It contains original articles on animal diseases in Africa, extracts and reviews of departmental annual reports and abstracts of special interest to veterinarians in Africa from hundreds of scientific periodicals.

The inaugural meeting of the Inter-African Advisory Committee on Epizootic Diseases took place at the same time. This Committee was established by the Member Governments of the C.C.T.A. to advise these Governments on the control of, and research into, epizootic diseases in Africa.

The Committee considered a report on the recent outbreak of rinderpest in buffaloes and other wild animals in the region north of the Equator along the common boundaries of the Belgian Congo, Sudan and Uganda. The subject of rabies was considered at length and it was recommended that a CCTA/WHO training course on laboratory techniques and field control be held in Africa in 1955. Several of the new diseases which have been established or are in danger of being introduced into Africa were considered. Special consideration will be given at the next meeting of the Committee to the questions of sero-diagnosis in contagious bovine pleuro-pneumonia, vaccination in foot-and-mouth disease in Africa, and bovine cutaneous streptothricosis.

W. G. BEATON,
Director.